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Revision 6

Documented Safety Analysis for the Reduction-Oxidation Facility

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

P.O. Box 1600
Richland, Washington 99352

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CH2M HILL Plateau Remediation Company

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Documented Safety Analysis for the Reduction-Oxidation Facility

Prepared by:

CH2M HILL Plateau Remediation Company
Richland, Washington

June 2016

Executive Summary

The Reduction-Oxidation (REDOX) Facility is a former fuel processing Canyon building located in the 200 West (200W) Area. The REDOX Facility was a continuous-flow, solvent-extraction process plant that was deactivated in the late 1960s. The building has not operated since that time and has been in surveillance and maintenance (S&M) mode for the last several years. The Documented Safety Analysis (DSA) for the REDOX Facility is maintained in accordance with 10 CFR 830, *Nuclear Safety Management*, and as such, is updated on an annual basis, as necessary, to reflect any changes in the facility, the work, or the hazards as they are analyzed in the DSA.

The 2016 update to this DSA includes several changes to the accident analyses; additionally, Section 3.4 and Section 4.3 have been updated to be more consistent with the guidance provided in DOE-STD-3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*.

The following technical changes have been made:

- All Damage Ratios (DRs), applied and postulated, have been removed. A DR of 1.0 is used for all scenarios.
- The Seismic Event now includes a failure of the 202-S Canyon and the 291-S Sand Filter simultaneously. The Sand Filter fails from a stack drop.
- Airborne Release Fraction (ARF) and Release Fraction (RF) values for accidents involving the 291-S Sand Filter have been updated with values of 1.2E-05 and 2.5E-01, respectively. A justification for the use of these values is provided.
- An Aircraft Impact Event, which involves a localized failure of the 202-S Building, has been added.
- The accident analyses in Chapter 3 were evaluated for use of the DOE-STD-3009-14 χ/Q value of 3.5E-03 sec/m^3, and updated as appropriate.
- The Waste Inventory Control Technical Safety Requirement (TSR) has been made into a Specific Administrative Control (SAC) to protect the assumptions made in the analysis.
- Section 4.3, "Administrative Controls" has been expanded to support the SACs.
- The TSRs have been updated for clarity and consistency.

The DSA was also updated to include multiple references to CHPRC-02595, *CSER-15-003: Criticality Safety Evaluation Report Surveillance and Maintenance Efforts for Contamination Remediation*. This Criticality Safety Evaluation Report (CSER) contains controls for remediation activities that impact fissile material that keep a criticality accident Beyond Extremely Unlikely (BEU).

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Appendices

Terms

AC	administrative control
AMU	aqueous makeup unit
ARF	airborne release fraction
BED	Building Emergency Director
CHPRC	CH2M HILL Plateau Remediation Company
CP	Central Plateau
CW	collocated worker
D&D	decontamination and decommissioning
DCF	dose conversion factor
DOE	U.S. Department of Energy
DR	damage ratio
DSA	Documented Safety Analysis
Ecology	Washington State Department of Ecology
ERDF	Environmental Restoration Disposal Facility
FHA	Fire Hazards Analysis
FW	facility worker
HC	hazard category
HSEAS	Hanford Site Emergency Alerting System
ICRP	International Commission on Radiological Protection
ISMS	Integrated Environmental, Safety, and Health Management System
KA	key attributes
LEL	lower explosive limit
LLW	low-level waste
LPF	leak protection factor
MAR	material at risk
MCC	motor control center
MLLW	mixed low-level waste
MPFL	maximum possible fire loss
MOI	maximally-exposed offsite individual
NFPA	National Fire Protection Association
NPH	natural phenomena hazard
PCB	polychlorinated biphenyl
PFP	Plutonium Finishing Plant
PMMA	polymethyl methacrylate
PR	product receiver
QA	Quality Assurance
REDOX	Reduction-Oxidation
RF	release fraction
SAC	Specific Administrative Control

SARAH	CHPRC Safety Analysis and Risk Assessment Handbook
S&M	surveillance and maintenance
SMP	safety management program
SSC	structure, system, and component
TED	total effective dose
TRU	transuranic (waste)
TSR	technical safety requirement
USQ	unreviewed safety question
WDOH	Washington State Department of Health
WG	weapons grade
WRPS	Washington River Protection Solutions

Chapter 1.0

Introduction

Contents

Figures

1.0 Introduction

1.1 Summary

This Documented Safety Analysis (DSA) provides the safety analysis requirements for the continued surveillance and maintenance (S&M) of the Reduction-Oxidation (REDOX) Facility. This DSA was developed in accordance with DOE-STD-1120-2005, *Integration of Environment, Safety, and Health into Facility Disposition Activities,* and PRC-PRO-NS-700, *Safety Basis Development.*

1.2 Facility Overview

The Hanford Site is an area of approximately 1450 km^2 (560 mi^2) located in the south-central corner of Washington State (Figure 1-1) The REDOX Facility is located in the 200 West (200W) Area of the Hanford Site (Figure 1-2). The REDOX Facility is a former fuel processing facility (i.e., formerly called the 202-S Canyon Building) and includes the following ancillary or support structures:

- 211-S Liquid Chemical Storage Tank Farm
- 276-S Solvent Handling Building
- 291-S Canyon Exhaust System (i.e., sand filter, exhaust fans, and exhaust stack)
- 292-S Control and Jet Pit House
- 293-S Nitric Acid Recovery and Iodine Backup Building
- 2708-S Lagger Storage Building
- 2710-S Nitrogen Storage Building
- 2711-S Stack Gas Monitoring Building
- 2715-S Storage Building
- 2718-S Sand Filter Sample Building
- 2904-SA Cooling Water Sampling Building

The facility consists of deactivated buildings and associated process equipment used for dissolution and separation of uranium, neptunium, and plutonium, as well as deactivated equipment used for waste concentration, waste neutralization, and solvent recovery. In addition to the main processing building (that was the 202-S Canyon Building), the REDOX Facility includes buildings formerly used for storing chemicals and materials, and support systems (e.g., ventilation).

The 202-S Canyon Building is a reinforced-concrete structure housing nine process cells and supports the deactivated operating, piping, sample galleries, and a tower process area referred to as the Silo. The process cells (e.g., Dissolver Cell A, South Extraction Cell F) contain deactivated processing equipment. The Silo contains deactivated solvent-extraction columns. The 202-S Canyon Building is serviced by the 291-S Exhaust Ventilation System. Exhaust air passes through a sand filter before being discharged to the environment.

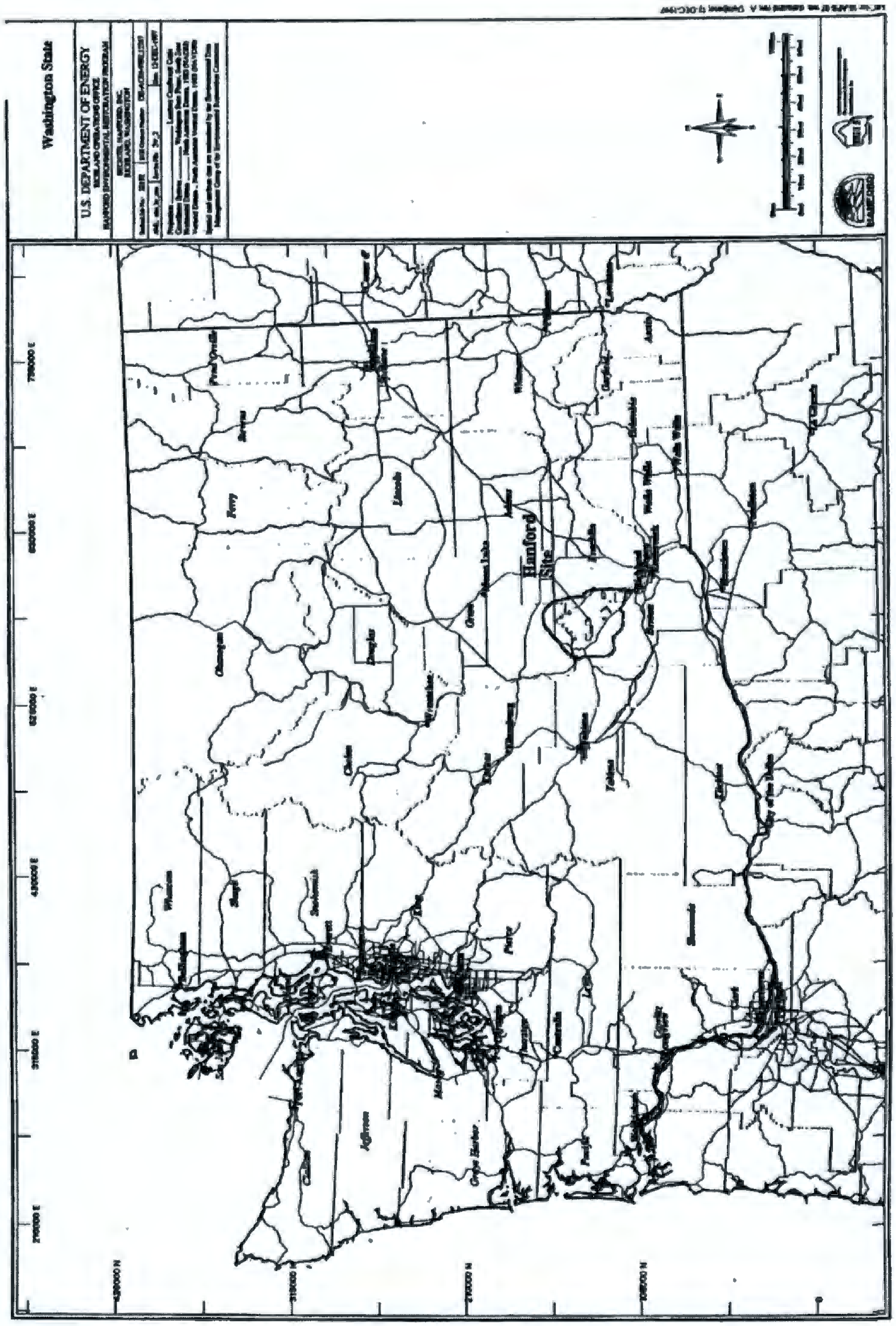

Figure 1-1. The Hanford Site's Location in Washington State

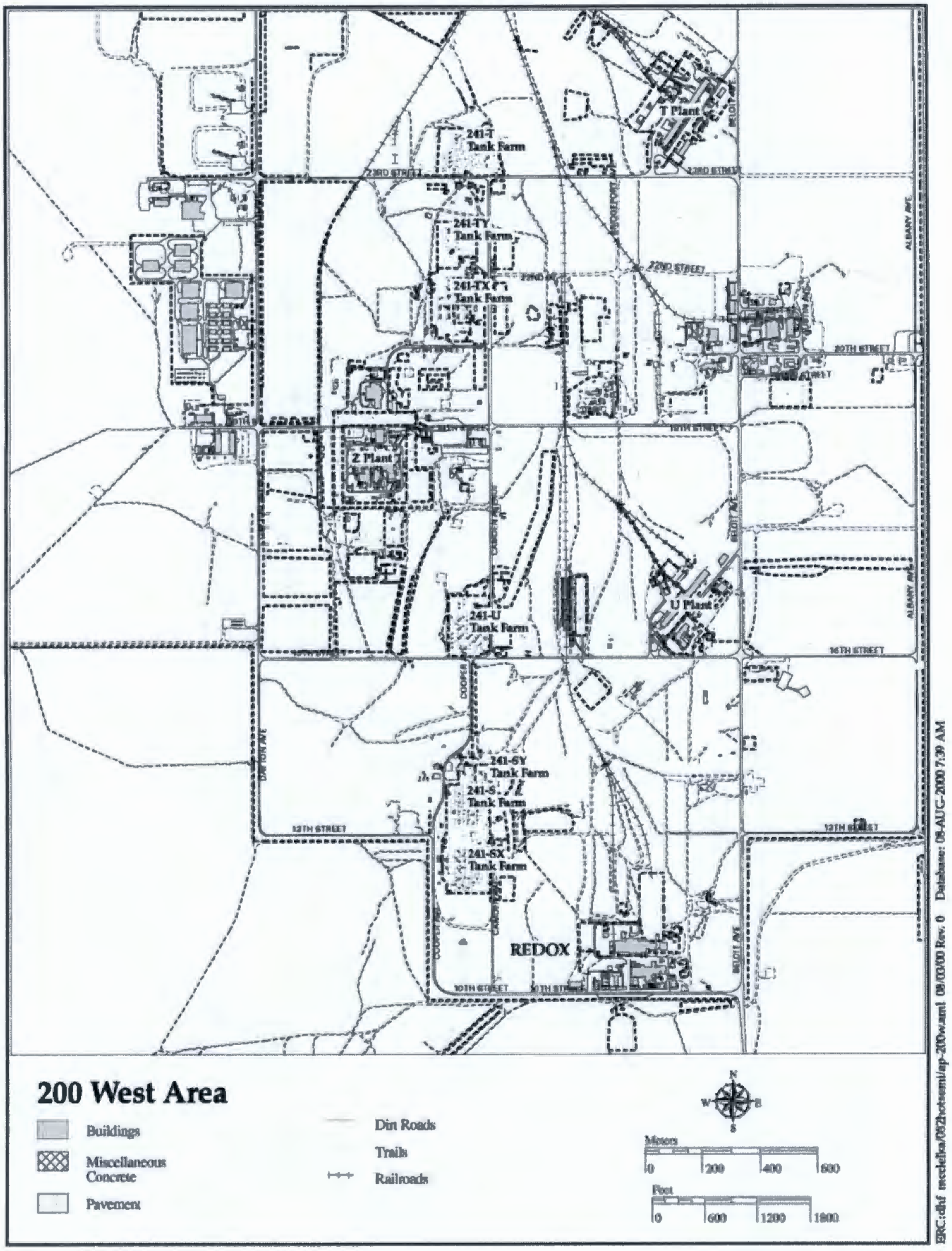

Figure 1-2. 200 West Area

The REDOX Facility, shown in Figure 1-3, was the first large-scale, continuous-flow, solvent-extraction process plant built in the United States for the recovery of plutonium from irradiated uranium fuel. Operations began in 1952 and continued until the facility was shut down in 1967. Deactivation started in 1967 and was completed in 1969. Since deactivation, S&M operations have been performed at the facility. Conduct of S&M activities constitutes the current facility mission.

1.3 Organizational Description

The U.S. Department of Energy (DOE) owns and has overall responsibility for the Hanford Site. CH2M HILL Plateau Remediation Company (CHPRC) is the prime contractor responsible for overall coordination and operation of many of the site facilities including the REDOX Facility. The Central Plateau (CP) S&M Organization is responsible for S&M at the REDOX Facility.

1.4 Planned Facility Activities

There are currently no operational processes ongoing at REDOX. During S&M, planned activities include periodic tours; maintenance of the ventilation system, compressed air system, and portions of the electrical distribution/lighting system; and corrective maintenance. A more detailed description is provided in Section 2.2, "Facility Life-Cycle Planned Activities."

Additional activities, which will facilitate future decontamination and decommissioning (D&D) of the REDOX Canyon, are included in Section 2. The activities within the Canyon are for maintenance, cleanup, and characterization of the facility. Respective DSA sections have been expanded to include these activities. The D&D activities outside the Canyon, in the REDOX yard, involve relatively low hazards and will reduce existing hazards and facilitate access for Canyon D&D. They are described in Section 2.2.14.

1.5 Summary of Facility Hazard Categorization

The REDOX Facility has been determined to be a hazard category (HC) -2 facility based on the sum-of-ratios approach described in DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*. The 202-S Canyon Building, the 291-S exhaust system (including the wind tunnel, exhaust fan equipment and stack) and the 292-S Building (exhaust condensate collection) are the components of the primary nuclear segment of the REDOX Facility. Buildings and external locations that may be used to stage waste containers (e.g., burial boxes and drummed waste) also are considered to be nuclear, based on the need to stage REDOX waste for disposal. Other buildings in the REDOX Facility may contain radiological contamination; however, the quantities are negligible to minor. The REDOX Facility is discussed in Section 2.3, Table 2-1, and Appendix A, Table A-2 of this DSA. Section 3.1.1, Table 3-2, summarizes the residual inventory used in the facility hazard categorization. The REDOX Facility is classified, for criticality purposes, as a limited-control facility because the contents may contain greater than half of a minimum critical mass. A criticality is determined to be incredible in HNF-36331, *CSER 08-002: Criticality Safety Evaluation Report for REDOX Facility in 200 West Area* where fissionable material is not disturbed. For activities affecting the form/distribution of the fissile material, a criticality is judged to be incredible per CHPRC-02595, *CSER-15-003: Criticality Safety Evaluation Report Surveillance and Maintenance Efforts for Contamination Remediation*.

1.6 Summary of Safety Analysis Results

The hazard and accident analysis for REDOX is described in detail in Chapter 3.0 of this DSA. The bounding accident scenario for REDOX is the seismic analysis (Section 3.4.1), which potentially results in a simultaneous structural failure of both the 202-S Building and the 291-S Sand Filter. This scenario results in consequences that are less than 1 rem Total Effective Dose (TED) to the Maximally-exposed Offsite Individual (MOI), and less than 25 rem TED to the Collocated Worker (CW) for the unmitigated accident scenario; thus, no Safety Significant (SS) or Safety Class (SC) structures, systems, or components (SSCs) are required for this natural phenomena hazard (NPH) event.

All other unmitigated accident scenarios identified in Chapter 3.0 also resulted in potential consequences that are less than 1 rem TED to the MOI and less than 25 rem TED to the CW. This corresponds to "low" risk for bounding accidents per the risk evaluation guidelines in PRC-STD-NS-8739, *CHPRC Safety Analysis and Risk Assessment Handbook (SARAH)*. As such, there are no SC or SS SSCs identified for mitigation or reduction of hazards. Defense-in-depth equipment is identified in Section 4.1.3.

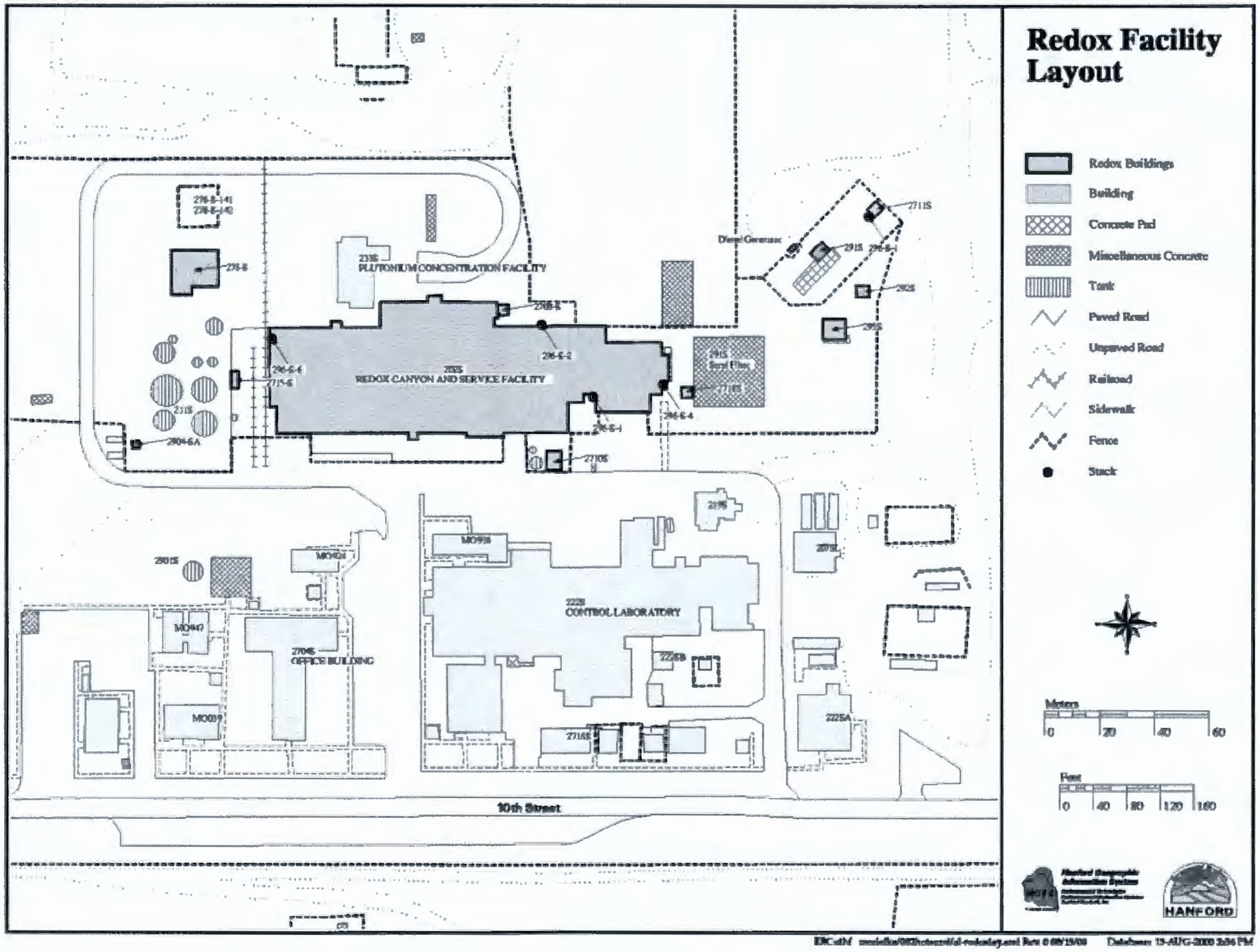

Figure 1-3. REDOX Facility

Chapter 2.0

Facility Description

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2.0 Facility Description

2.1 Facility Operational History

The REDOX Facility (also known as S Plant or the 202-S Facility) is located in the southwest portion of the 200W Area of the Hanford Site. The REDOX Facility was constructed in accordance with the design codes, standards, and regulations in place at the time of construction.

The REDOX Facility, which was constructed between 1950 and 1952, was the first large-scale, continuous-flow, solvent-extraction process plant built in the United States for recovering plutonium from irradiated uranium fuel. The extraction process, which replaced the batch precipitation methods first used at the Hanford Site, was designed to separate uranium, plutonium, and neptunium as individual product streams from associated fission products in the irradiated fuel. The plant operated from 1952 until 1967. Deactivation started in 1967 and was completed in 1969, when the REDOX Facility was transferred to S&M status. Further details regarding the REDOX deactivation can be found in ISO-1108, *REDOX Deactivation Manual.* Deactivation included multiple flushes using water, diluted hot nitric acid, permanganate, and oxalic acid. The facility was flushed regularly with water for nearly a year after the initial cleaning.

The deactivated REDOX Facility contains buildings and process equipment formerly used for dissolution and separation of uranium, neptunium, and plutonium, as well as deactivated equipment formerly used for waste concentration, waste neutralization, and solvent recovery. In addition to the main process areas, the REDOX Facility includes buildings that were formerly used to store chemicals and materials and support systems (e.g., ventilation, exhaust stacks, and environmental monitoring systems). The REDOX Facility will remain unoccupied for the duration of S&M activities.

2.2 Facility Life-Cycle Planned Activities

There are currently no operating processes in the REDOX Facility, since it is in shutdown mode. During the current facility life-cycle phase, planned activities will consist primarily of S&M as addressed in DOE/RL-98-19, *Surveillance and Maintenance Plan for the 202-S Reduction Oxidation (REDOX) Facility*. The storage of supplies and materials related to S&M activities and limited deactivation activities are authorized. Active facility systems are limited to the ventilation system and portions of the electrical distribution/lighting system.

The scope of work includes S&M that maintains confinement of hazardous substances and protects the worker and some additional activities to facilitate future D&D. This work scope includes pre-approved activities for surveillance of the facility, preventative maintenance of selected equipment, and incidental storage of necessary supplies and equipment. The work scope also includes activities that are anticipated but not defined by pre-approved procedures. Examples of anticipated activities without pre-approved procedures include specific asbestos abatement actions; replacement or upgrades of postings and barriers; container management; demand repairs to SSCs; spill response; characterization; and response or investigation of non-typical surveillance reports. Characterization, sampling, and (if needed) decommissioning of boreholes (wells) are also included in the authorized work scope. The boreholes (wells) are to be located and operated in such a way that they do not compromise the function or integrity of any facility SSC or program credited with a safety function. Programmatic controls described in Chapter 5.0 are in place to ensure that S&M activities are performed within the safety basis and protect the workers.

The Unreviewed Safety Question (USQ) process is a programmatic control used to aid in change management. Pre-approved procedures, when revised, are screened and evaluated as required under USQ requirements. Original and revised demand work packages are screened and evaluated as required under the USQ process. Non-typical surveillance reports, audits, and similar documents are reviewed to determine if they meet the criteria for safety evaluations under the discovery requirements of the USQ process.

2.2.1 Routinely Surveyed Areas

Routine surveillances are implemented by approved procedures. Figures 2-1 through 2-15 show areas that are surveyed periodically.

2.2.2 Surveillance and Maintenance of Barriers and Postings

Barriers and postings are used to prevent unwarranted access to hazardous areas and to inform personnel of conditions that exist at the REDOX Facility. Barriers and postings consist of locks and tags, door locks, fencing, confined-space postings, and radiological-area postings. Barriers and postings are installed and inspected as part of the S&M activities, as specified in work instructions. Discrepant conditions regarding barriers or postings are identified on associated data/inspection sheets and corrected.

2.2.3 Identification and Removal of Asbestos

Asbestos-containing materials or presumed asbestos-containing materials are inspected before renovation or demolition activities. If damaged friable asbestos is encountered, the actions to be taken will depend upon the scope and severity of the damage. Repair, encapsulation, or removal will be managed through the hazardous material control program requirements of the safety management program (SMP). Wide-scale removal of asbestos materials, where that is the primary purpose of the activity, is not permitted. Asbestos removal activities that support authorized repair activities are authorized. Examples are:

- Asbestos removal required to support repair, removal, or modification of components
- Removal of damaged asbestos
- Asbestos removal as part of demolition activities for buildings or components in the yard

2.2.4 Container Management

Normally, relatively small volumes of waste are accumulated during S&M activities. Risk reduction actions or other non-routine activities provide the need for conservative contingency plans. Designated areas may be used to accumulate waste before shipping. Transuranic (TRU) waste staged for transport is placed in waste containers that comply with applicable shipping and disposal requirements. The addition of outside radiological material is not allowed under this

DSA; this requirement does not apply to instrument check sources, calibration check sources, and contaminated tools or equipment.

Surveillance activities include inspecting existing containers, as well as sampling, identifying, and labeling unlabeled containers. TRU containers are removed and transported to a permitted storage facility for treatment, storage, and/or disposal. Periodic container inspections are performed to identify container deterioration or signs of leakage. If a deteriorating or leaking container is found, the situation is evaluated and actions are taken based on the severity of the situation, e.g., the container may be monitored, repackaged, or moved to an appropriate treatment/disposal facility. Corrective action is taken, when applicable, to prevent recurrence. The activities are managed consistent with applicable requirements of the hazard material control, work control, fire protection, and radiological protection programs.

Occasional use of Environmental Restoration Disposal Facility (ERDF) roll-off waste boxes or other containers designated low-level (LLW) or mixed low-level waste (MLLW) is anticipated. No accident analysis or controls are required for this minimal LLW waste stream. The activities are managed in compliance with applicable requirements of the radioactive and hazardous waste management, hazardous material control, work control, fire protection, and radiological protection programs.

2.2.5 Equipment Calibration, Testing, Maintenance, and Repair

Calibration and testing are conducted as appropriate on equipment such as level monitoring systems, ventilation systems, and electrical components. Elements and schedules for these activities are included in the procedures and task instructions.

2.2.6 Repair and Upgrades of Confinement Systems

Repairs will be made to the REDOX confinement systems as necessary to maintain system capability. Upgrades or physical changes to these systems may be undertaken if the changes provide equivalent or improved confinement. Maintenance and repair are also performed. Proposed changes will be evaluated individually to determine if these are within the bounds of the safety analysis as required by the Work Control and USQ programs.

2.2.7 Repair and Upgrades of Structural Components

Structural components necessary to ensure confinement will be repaired or upgraded as needed to maintain control of hazardous substances. Proposed changes will be evaluated individually to determine if these are within the bounds of the safety analysis as required by the Work Control and USQ programs.

2.2.8 Inspection for and Response to Spills

The REDOX Facility is surveyed routinely for indications of spills of hazardous substances. If a spill is discovered, the affected area will be isolated to prevent personnel exposure, corrective measures will be determined, and the spilled material will be packaged and shipped to an appropriate disposal facility in compliance with requirements of the Hazardous Materials Control Program.

2.2.9 Removal and Disposal of Hazardous Waste

Any hazardous substance removed from the REDOX Facility may, after proper waste designation, be disposed of at ERDF or at another approved disposal facility, as appropriate. Wastes will be packaged and shipped to an appropriate disposal facility in compliance with requirements of the Hanford Hazardous Materials Control Program.

Repairs will be made to the REDOX components as necessary to contain hazardous materials. This includes repairs to components with visible leakage or residue. When appropriate, this includes partial draining of systems, component removal, cutting and capping of lines, etc.

Cleanup of contamination areas is permitted, including application of authorized fixatives.

2.2.10 Nondestructive Assay Waste Characterization and Sampling

Nondestructive assay, waste characterization, and sampling may be performed in the REDOX Facility. The activities will be performed in accordance with established programs and procedures and shall comply with special controls (e.g., criticality reviews) as established in this DSA. These activities may be performed to better identify and characterize radioactive material inventory and location, determine quantity and makeup of newly discovered material, or support planning for eventual disposition. Characterization activities such as recording radiation and contamination levels, making video recordings, and sampling residues are included.

2.2.11 Removal of Equipment and Legacy Waste

Equipment and Legacy Waste (e.g., abandoned conduits, deactivated electrical equipment, contaminated vessels and piping, expired fire extinguishers, containers, etc.) may be removed from the REDOX Facility to reduce the risks from known hazards and to redeploy obsolete equipment as spare and replacement equipment (e.g., switchgears and motor control centers [MCCs]). These SSCs may contain surface contaminants. Removal and redeployment activities will be performed in accordance with established programs and procedures.

2.2.12 Radiological Surveys

Radiological surveys are performed to support S&M activities and are performed in accordance with established programs and procedures.

2.2.13 General Inspections and Tours

General inspections and tours may be performed separately from S&M activities. Inspections and tours will be conducted in accordance with appropriate programs and procedures.

2.2.14 D&D Activities in the REDOX Yard

The D&D activities described below are authorized to limit the hazards outside of the REDOX Canyon and to facilitate future D&D of the REDOX Facility.

Cleanup/removal of components in the REDOX yard (e.g. steam lines, electrical components, and other components such as tanks that are no longer in use).

D&D activities (partial or complete) of the following <HC-3 structures and associated tanks outside the Canyon that are listed in Table 2-1:

211-S, 276-S, 293-S, 2708-S, 2710-S, 2711-S, 2715-S, 2718-S, 2904-SA

It includes removal of retained liquids by draining or adding absorbent material, removal of asbestos and other hazardous materials, and removal of components.

This does NOT include:

- 202-S Admin/Office Areas due to common boundaries with 202-S Canyon.
- 292-S due to REDOX exhaust system operational considerations.
- 240S151 Diversion Box, 240S302 Catch Tank, 2712-S – owned by Tank Farms.

2.3 Facility Description

The physical layout of the REDOX Facility is shown in Figure 1-3 and the buildings included in the REDOX Facility are listed in Table 2-1. The structures identified as HC-3 were assessed to potentially exceed the HC-3 quantity of material based on process knowledge, inspection, and historical information. The structures identified as less than HC-3 were assessed to have less than an HC-3 quantity of material based on process knowledge, inspection, and historical information. The REDOX physical boundary includes the buildings with greater than HC-3 inventory (identified as 202-S, 291-S, and 292-S), plus the yard area within the fence surrounding the facility (excluding marked Washington River Protection Solutions (WRPS) Tank Farm facilities), and any active containments or waste queues supporting building activities, including the vehicle access route to each queue. While these WRPS facilities are on the REDOX Facility footprint and within 100 m of the REDOX Facility, they are maintained and operated by WRPS. In the event of an emergency at REDOX, potentially affected WRPS personnel would be notified and instructed on what emergency actions to take through the Hanford Site Emergency Alerting System (HSEAS) operated by the Hanford Site Emergency Management organization. Other contractors that may be located within 100 m of the facility would also receive emergency notification and instruction through the HSEAS. Specific response actions to an event at REDOX may also be directed by the S&M building emergency director (BED).

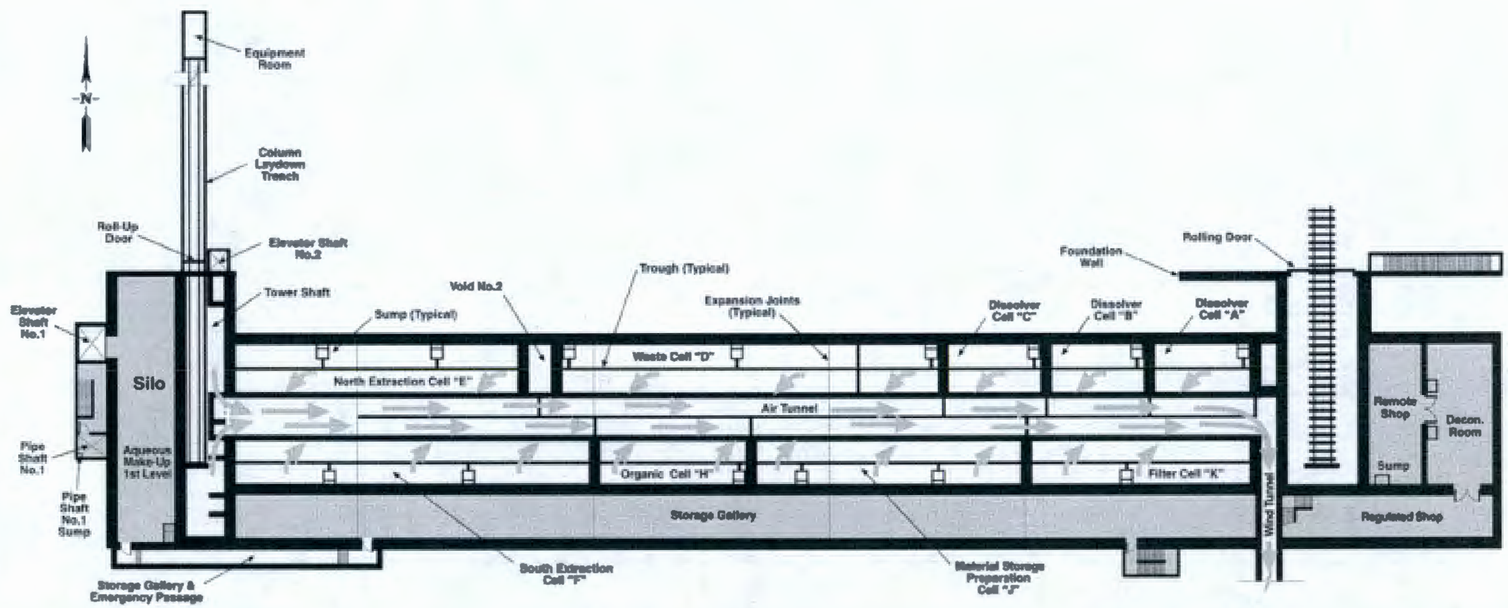
Figures 2-1 through 2-6 show general floor plans of the 202-S Canyon Building. More detailed floor plans are provided in Figures 2-7 through 2-15. Building sections and elevations are depicted in Figures 2-16 through 2-24.

Table 2-1. REDOX Facility Above-Grade Structures

Building Number	Building Name	Inventory and Segmentation Summary	Building / Structure Hazard Category
202-S	Canyon and Service Building	Contains significant residual inventory or contamination remaining from deactivation.	HC 2
211-S	Liquid Chemical Storage Tank Farm	Former chemical storage tanks emptied and deactivated. No significant inventory remains.	< HC 3
233-S	Plutonium Concentration Facility	Demolished	< HC 3
276-S	Solvent Handling Facility	Former chemical storage and recycle, which is inactive and isolated.	< HC 3
291-S	Canyon Exhaust System	Provides active exhaust of former Canyon process areas. The 291-S sand filter provides filtrations and retains significant inventory. Also includes wind tunnel, EF-1 and EF-2 fans, and the 291-S-1 stack.	HC 2 (common with 202-S Canyon Building)
292-S	Control and Jet Pit House	Facility is inactive except for condensate capacities for the 291-S exhaust system. Minor inventories reside, but the condensate capacity is required for exhaust operations.	HC 2 (common with 291-S exhaust)
293-S	Nitric Acid Recovery and Iodine Backup	Facility is deactivated and minor amounts of radiological contamination remain.	< HC 3 *
2706-S	Storage Building	Demolished (contaminated slab w/ overburden)	< HC 3
2708-S	Lagger Storage Building	Used for miscellaneous storage. Negligible contamination remains.	< HC 3
2710-S	Nitrogen Storage Building	Deactivated and isolated facility with negligible amounts of contamination suspected to remain.	< HC 3
2711-S	Stack Gas Monitoring Building	Deactivated with minor amount of contamination assumed to remain.	< HC 3 *
2715-S	Storage Building	Building may be used to store packaged waste to support REDOX activities.	< HC 3 *
2718-S	Sand Filter Sample Building	Deactivated and isolated from the plant. Minor amounts of contamination are assumed to remain.	< HC 3 *
2904-SA	Cooling Water Sampling Building	Deactivated and isolated facility with negligible to minor amounts of contamination assumed to remain.	< HC 3

Notes:

* The basis for downgrading 293-S, 2711-S, 2715-S, and 2718-S to <HC 3 is provided in CP-59461, *293-S, 2711-S, 2715-S, and 2718-S Hazard Categorization.*



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Ref. HW-18700 / Figure XI-5b / From DWG. H-2-7402

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Figure 2-1. Cell Floor Level Plan View

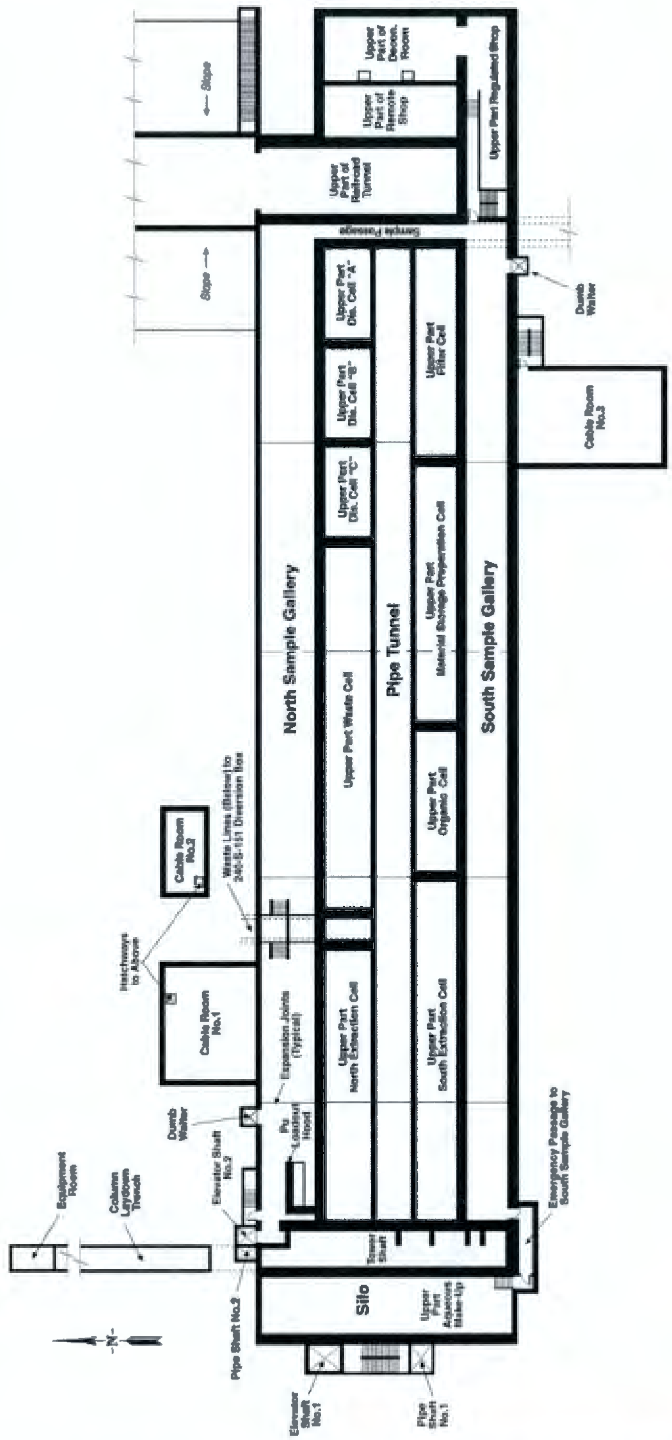

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Figure 2-2. Sample Gallery Level Plan View

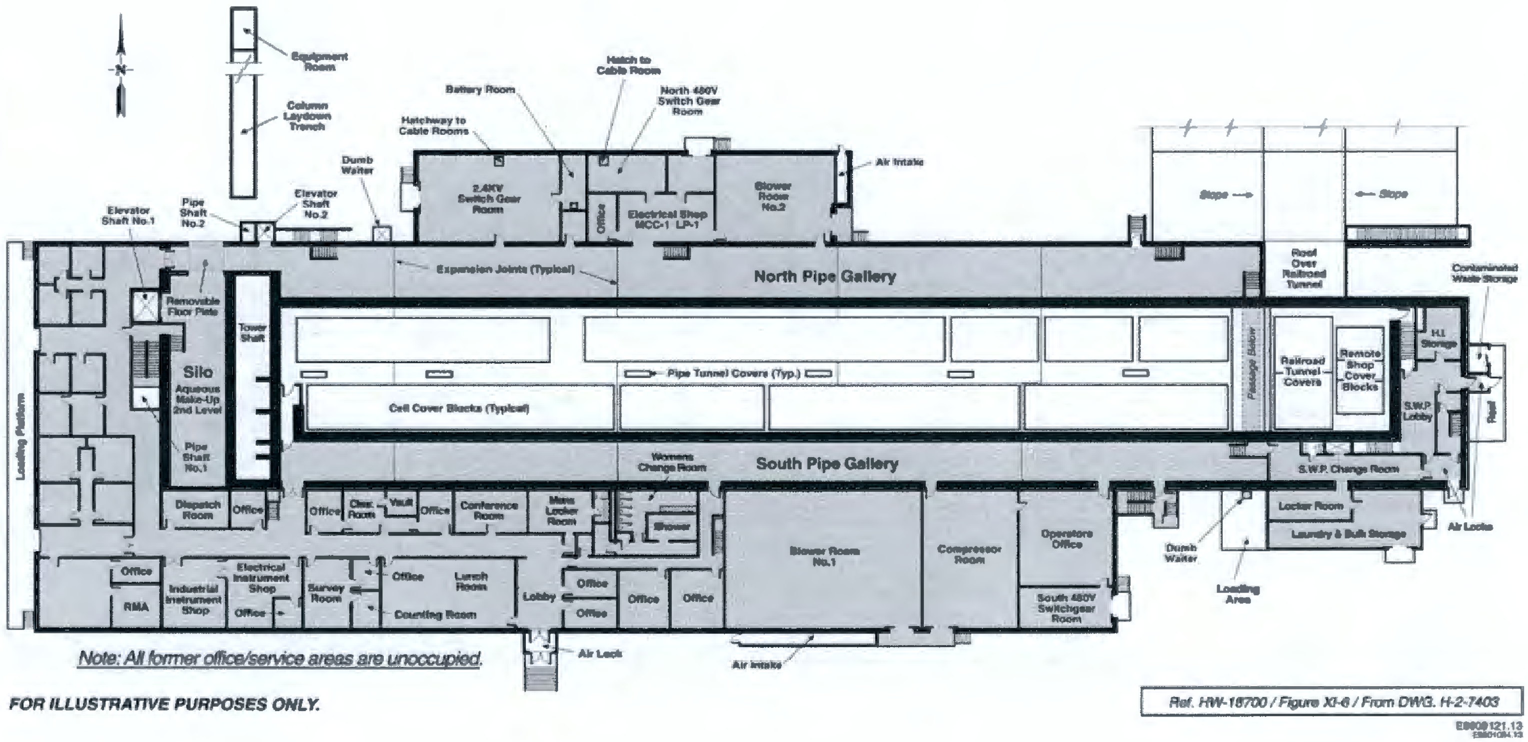

Figure 2-3. Pipe Gallery Level Plan View

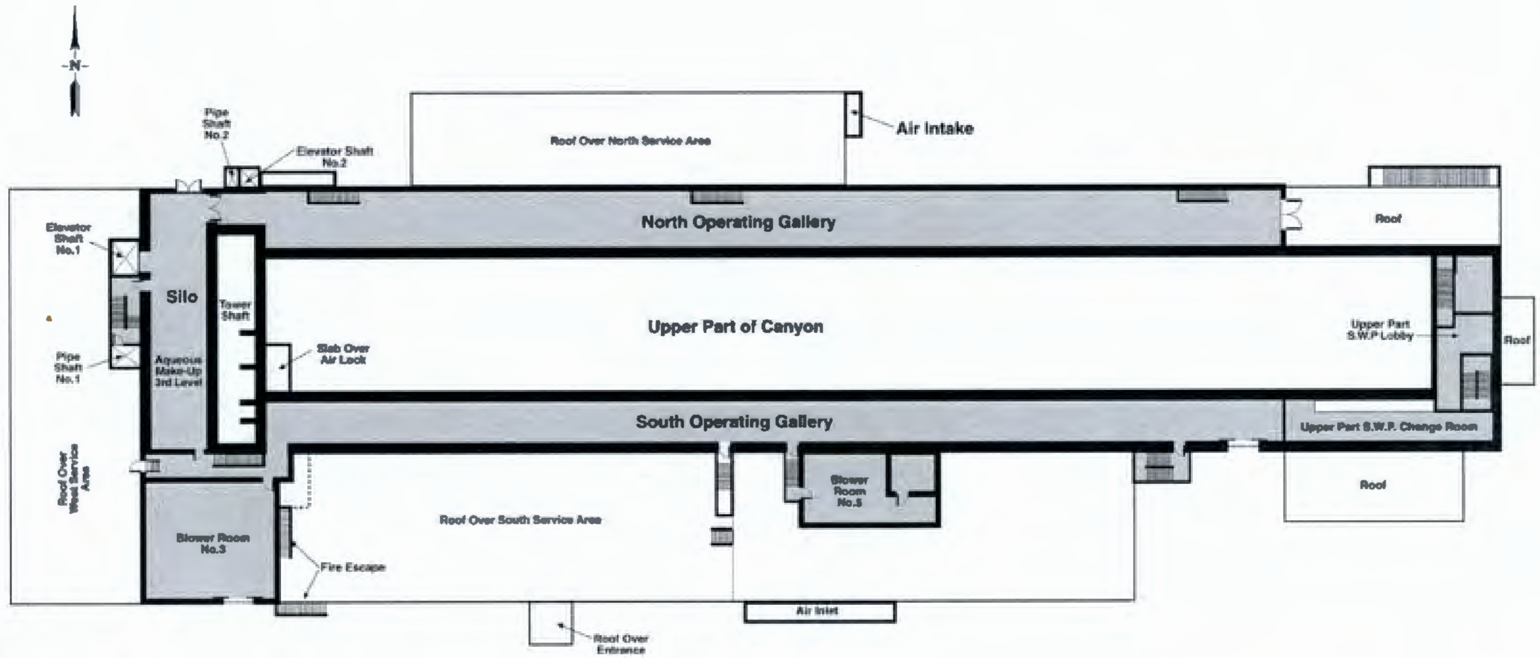

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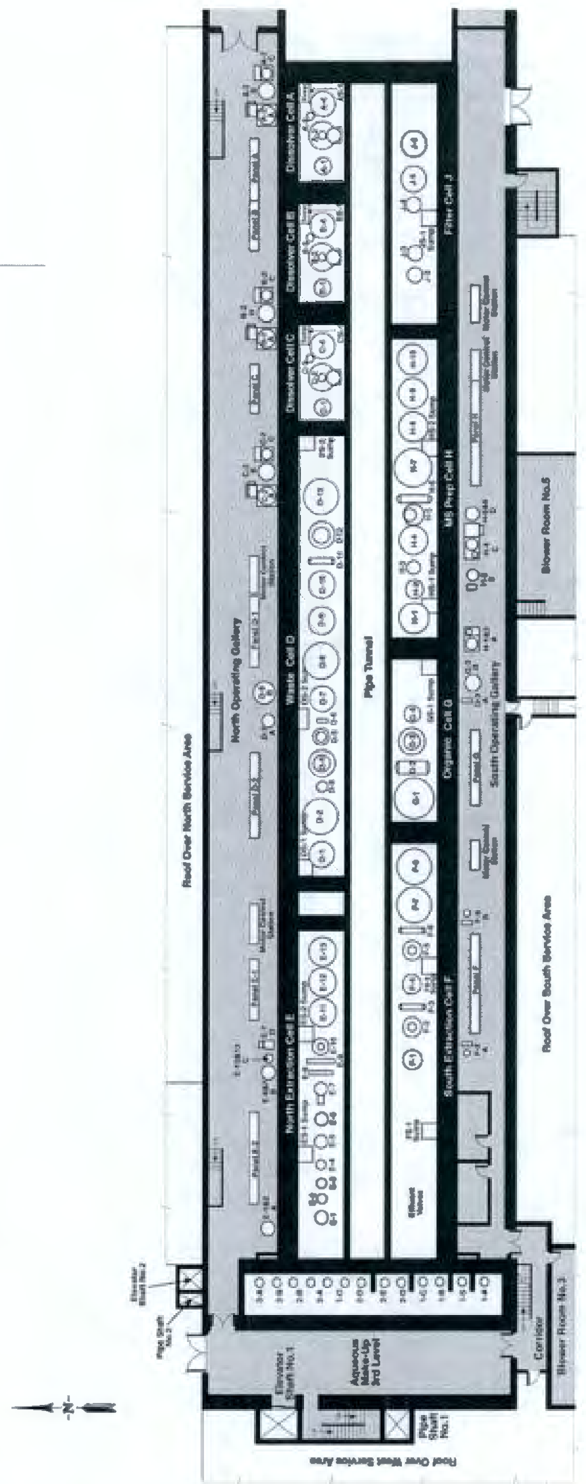
Figure 2-4. Operating Gallery Level Plan View



Ref. HW-18700 / Figure XI-9 / From DWG. H-2-8010, and DWGS. H-2-9441 Thru H-2-9472

FOR ILLUSTRATIVE PURPOSES ONLY.

Figure 2-5. North and South Operating Gallery Process Equipment Arrangement Plan View

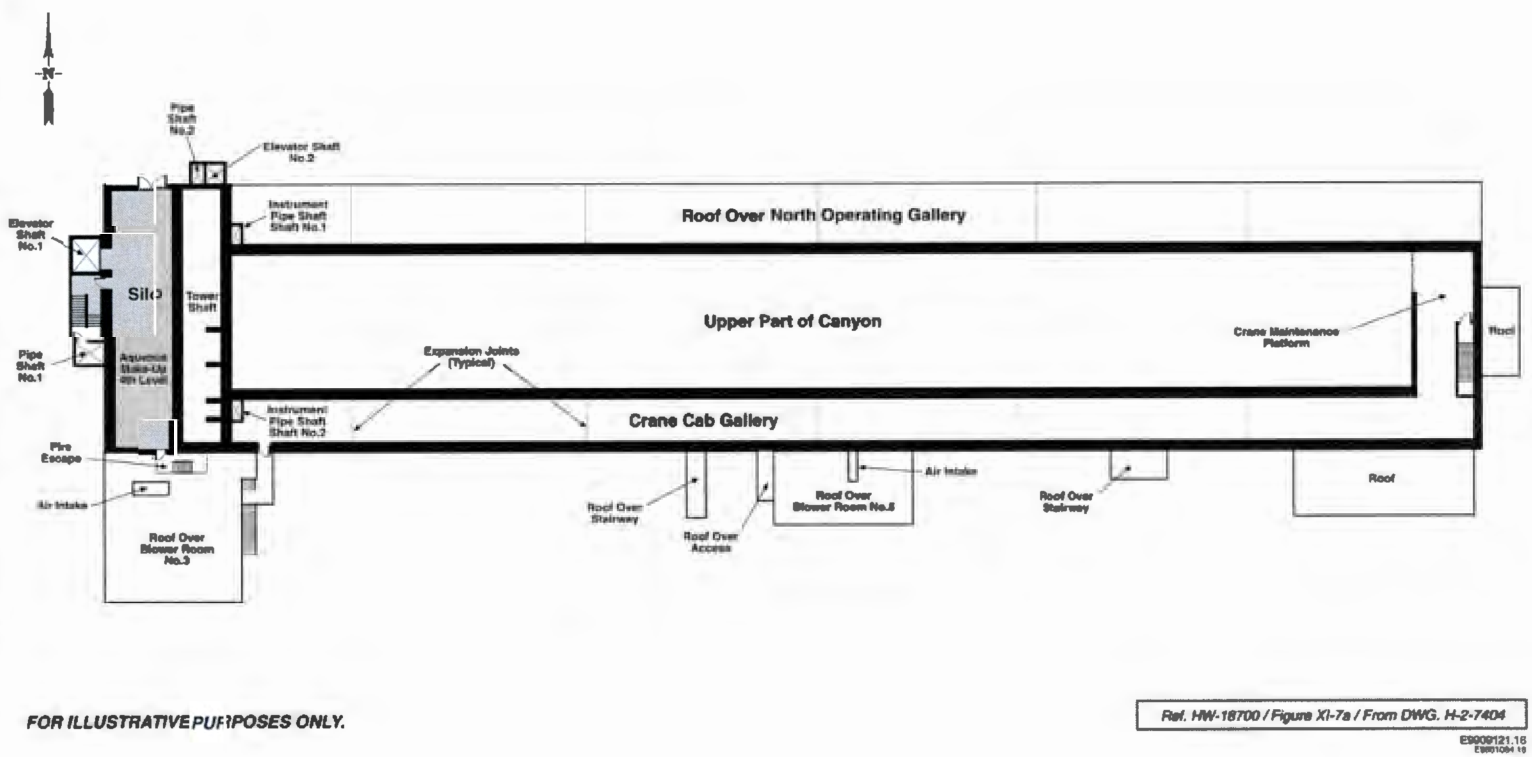


Figure 2-6. Above Crane Cab Gallery Level Plan View

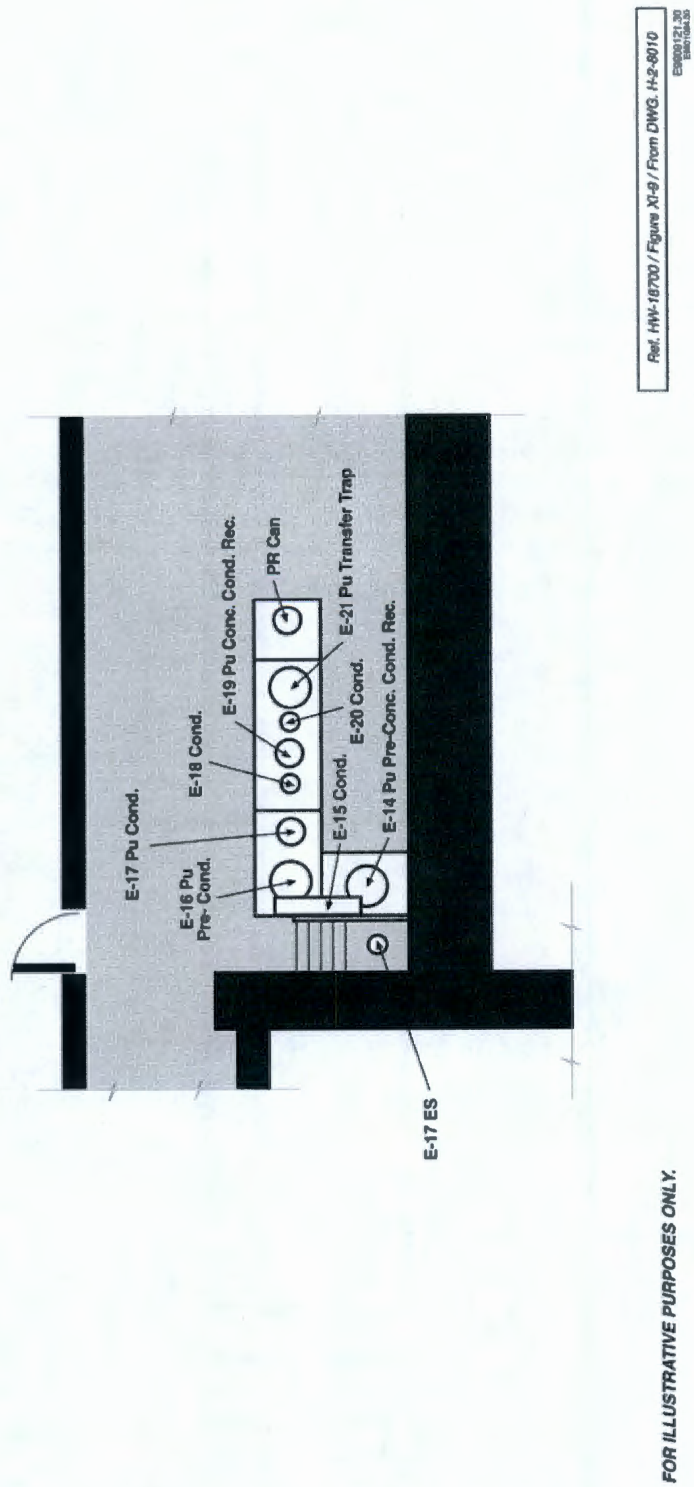


Figure 2-7. Product Receiver Cage in North Sample Gallery Plan View

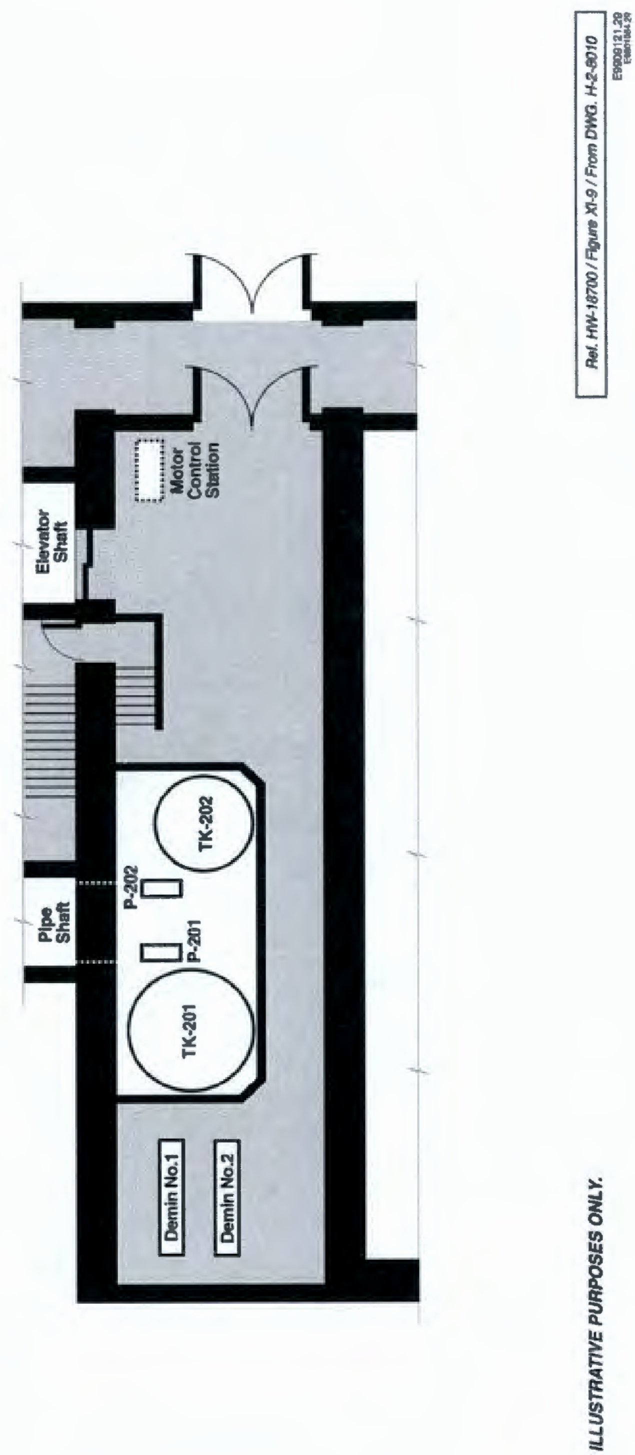
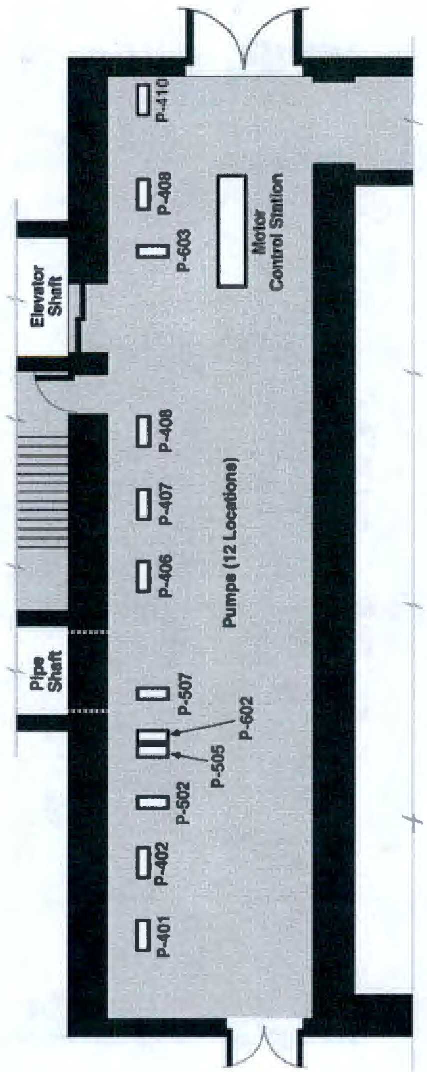


Figure 2-8. Silo Processing Aqueous Makeup, Second Level, Plan View

Ref. HW-18700 / Figure XI-9 / From DWG. H-2-8010

E9909121.28



FOR ILLUSTRATIVE PURPOSES ONLY.

Figure 2-9. Silo Processing Aqueous Makeup, Third Level, Plan View

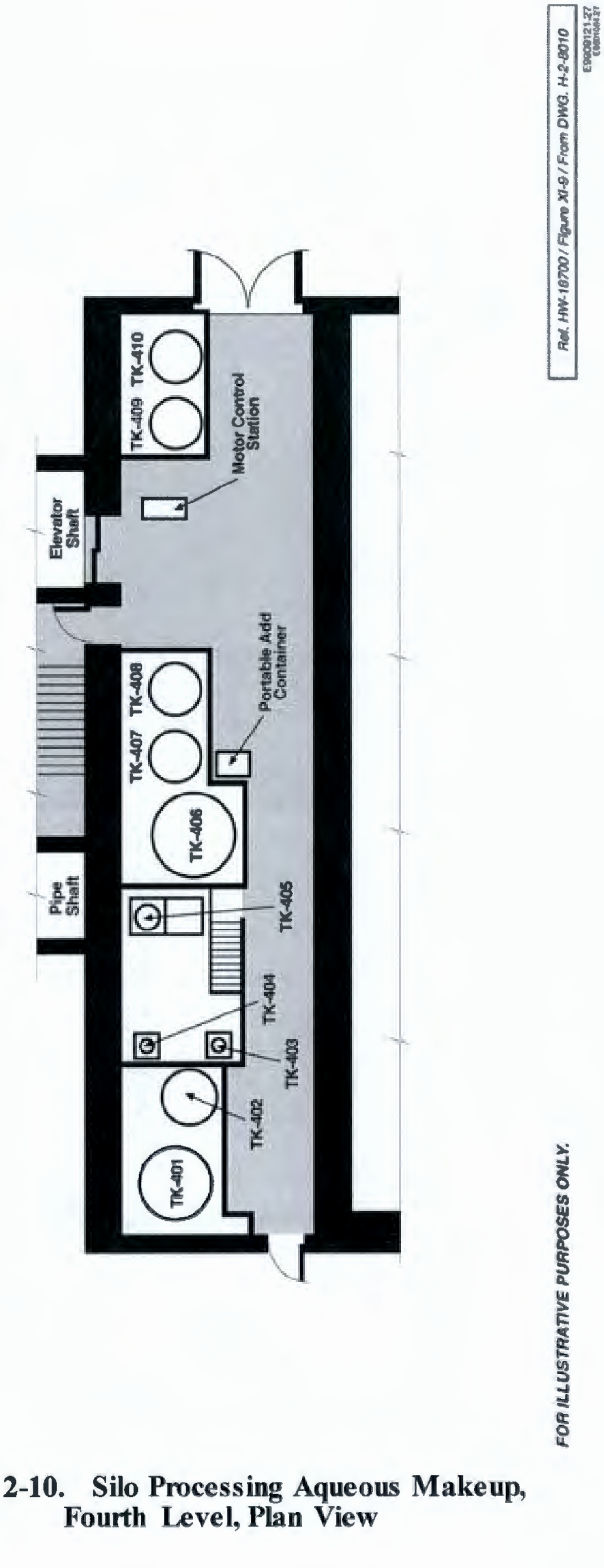


Figure 2-10. Silo Processing Aqueous Makeup, Fourth Level, Plan View

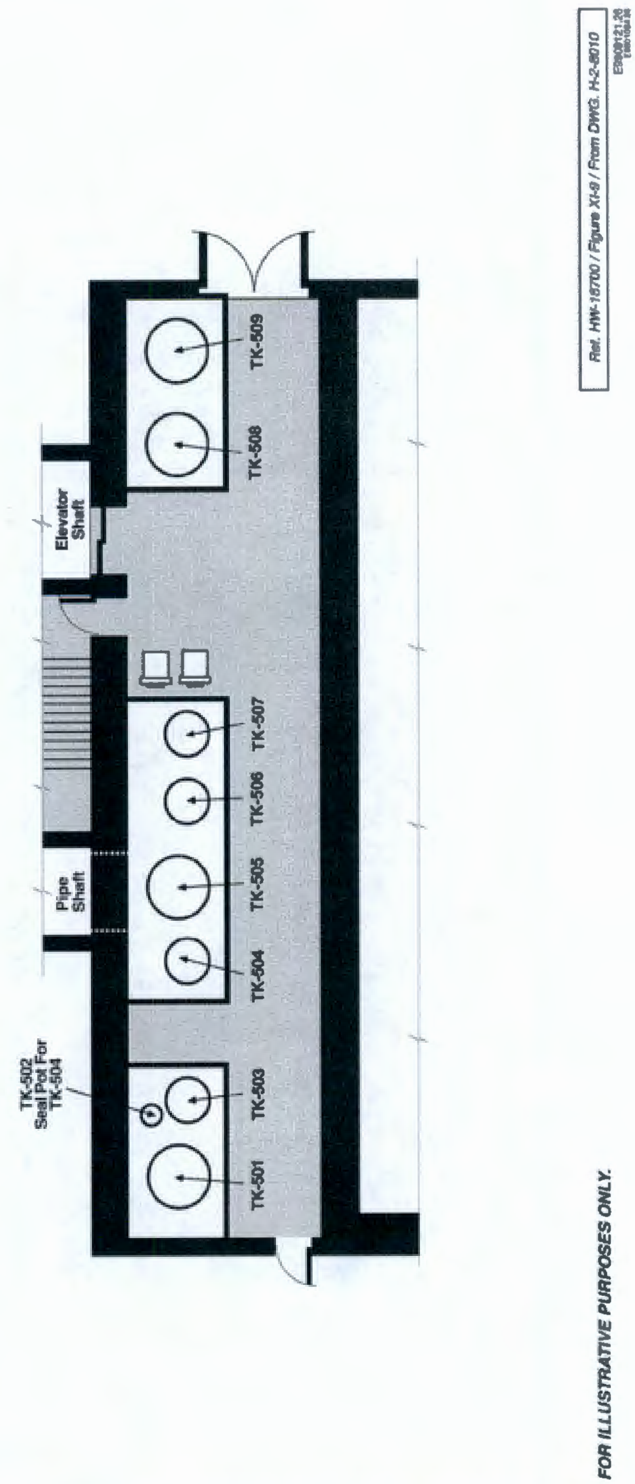


Figure 2-11. Silo Processing Aqueous Makeup, Fifth Level (Lower Part), Plan View

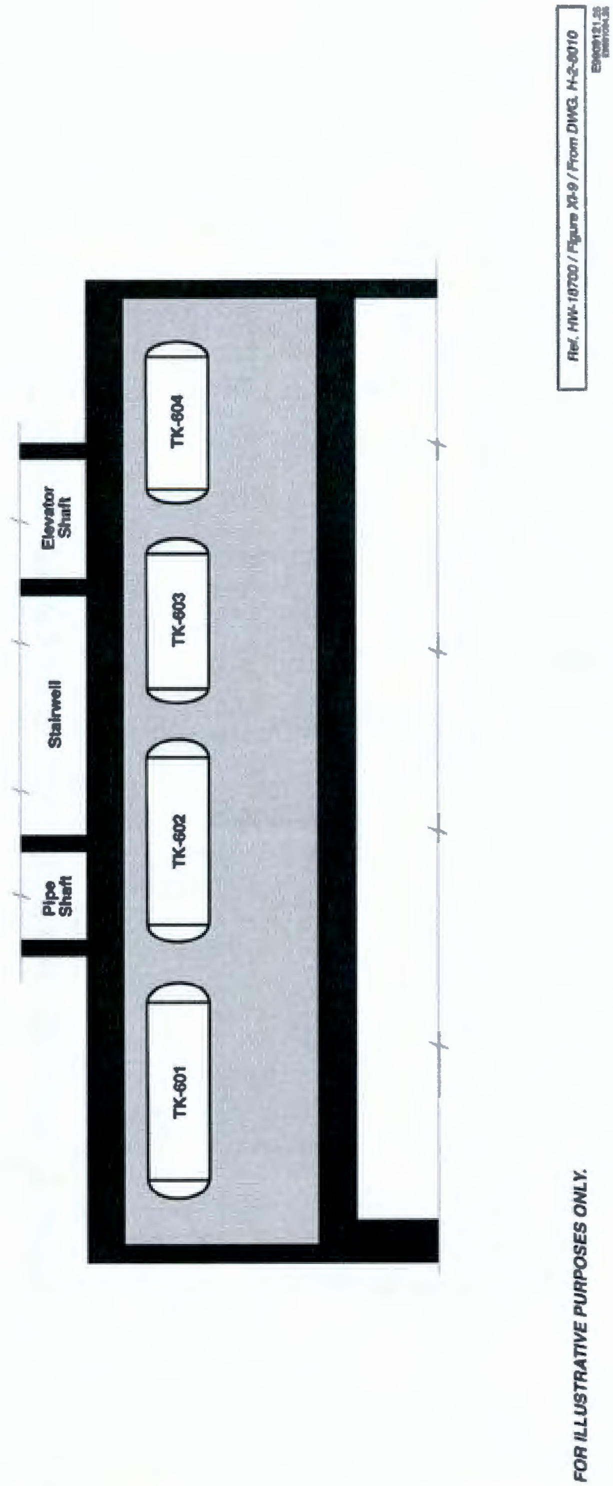


Figure 2-12. Silo Processing Aqueous Makeup, Fifth Level (Upper Part), Plan View

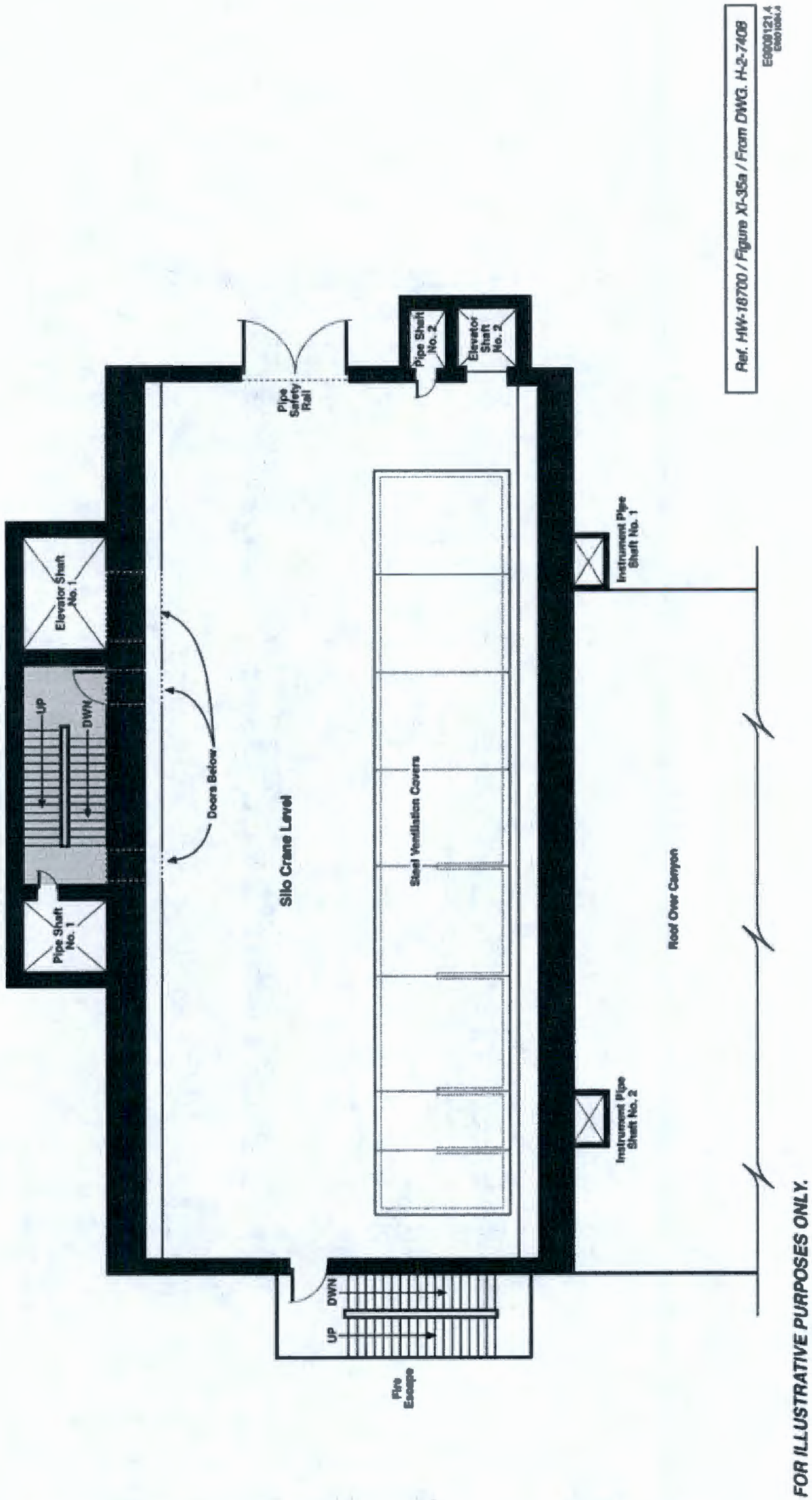
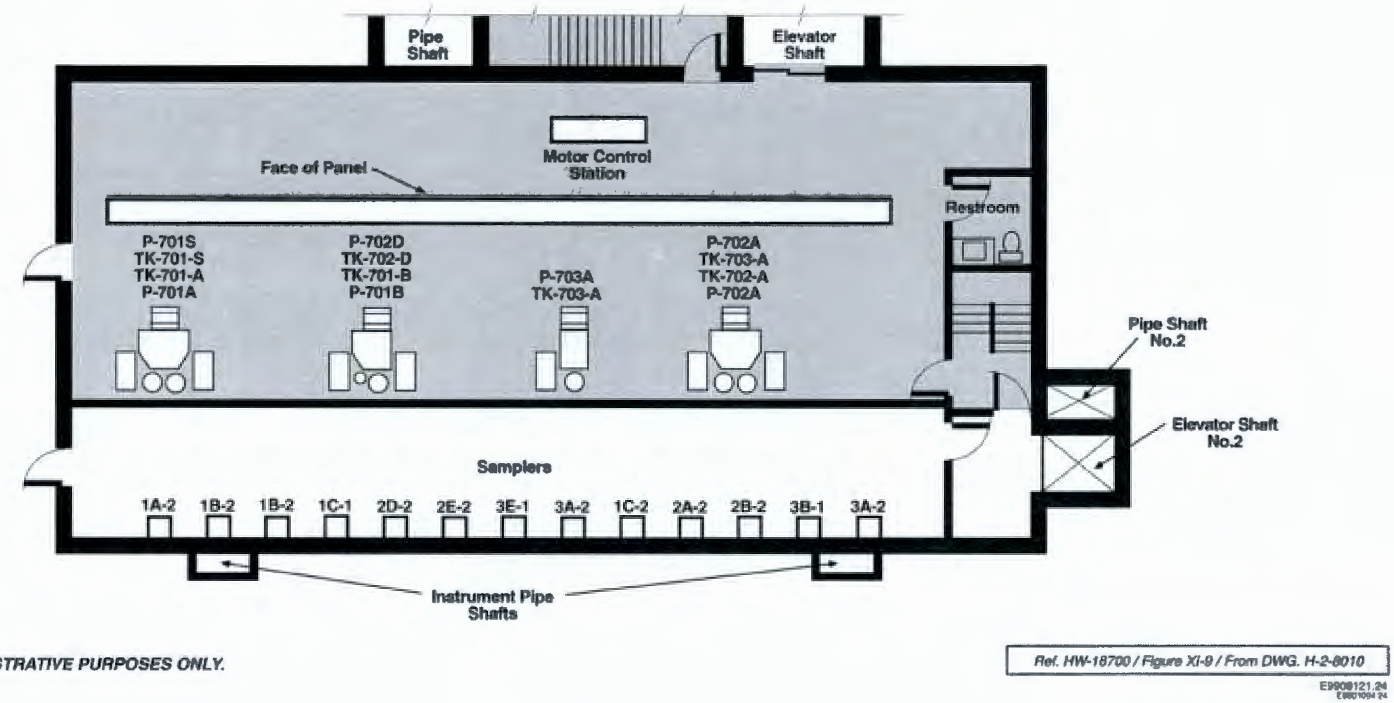


Figure 2-13. Silo Crane Level, Sixth Level, Plan View



FOR ILLUSTRATIVE PURPOSES ONLY.

Figure 2-14. Silo Processing Operating and Sample Galleries, Seventh Level, Plan View

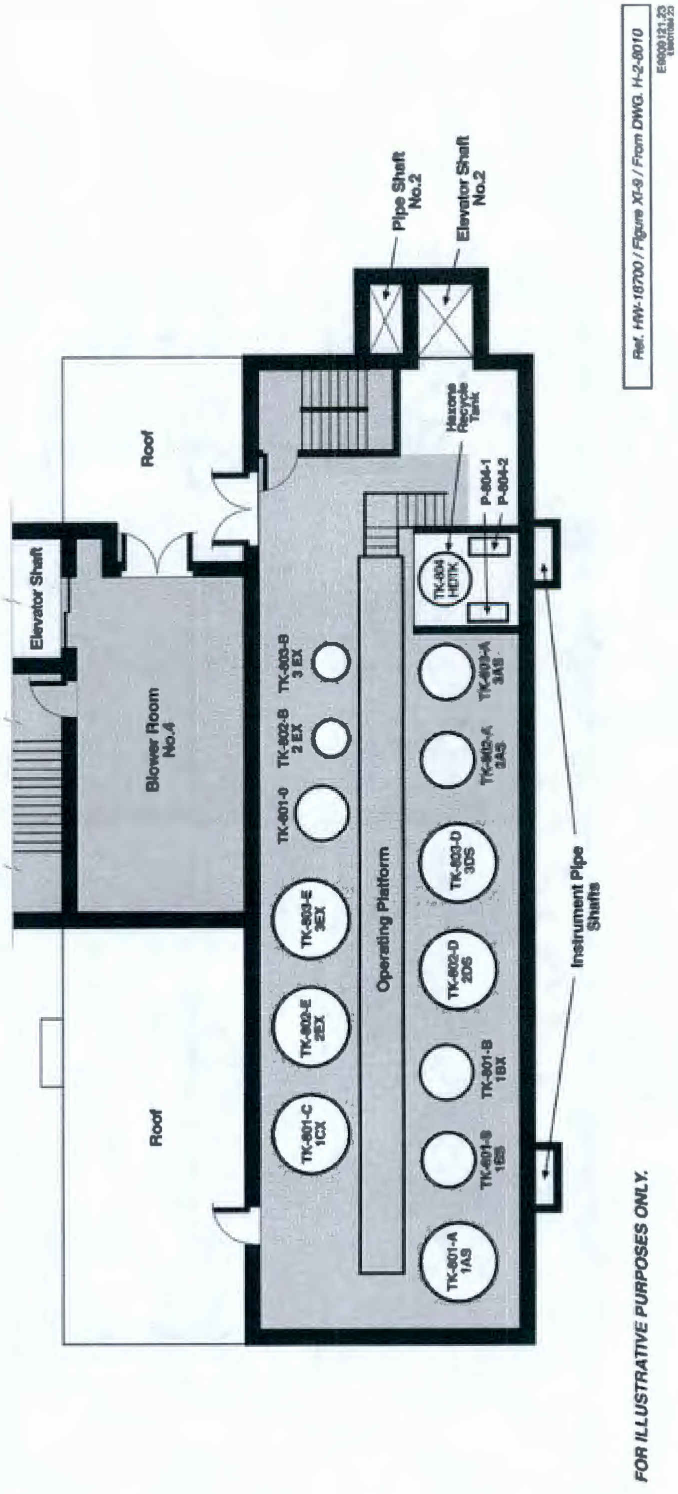


Figure 2-15. Silo Processing Operating and Sample Galleries, Eighth Level, Plan View

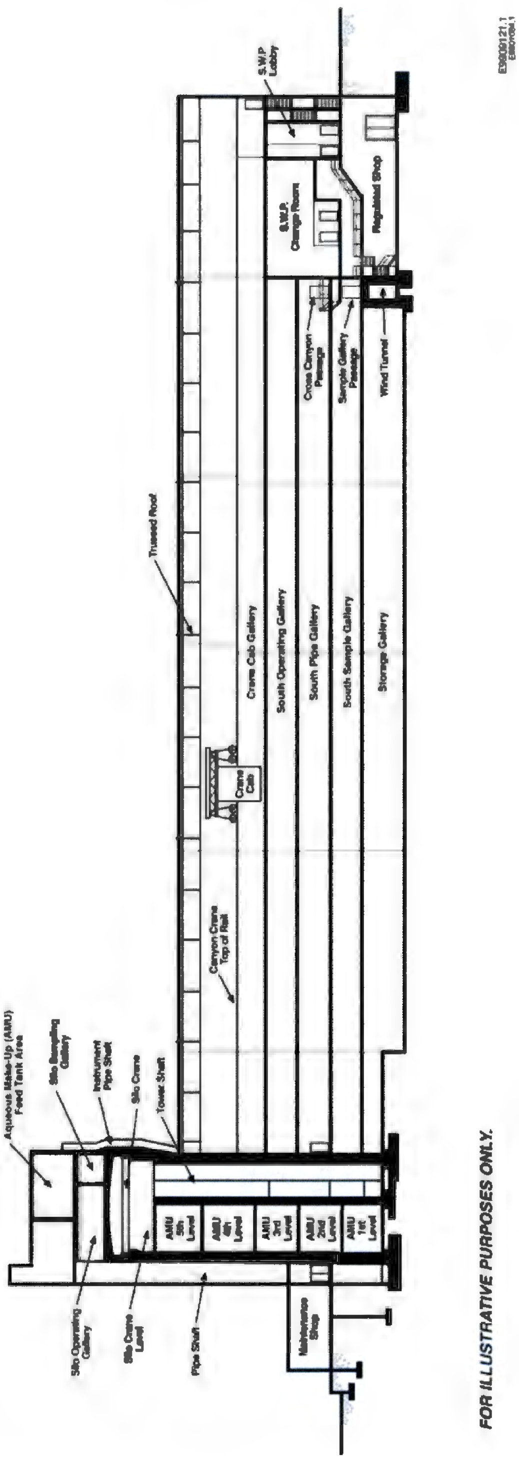


Figure 2-16. Longitudinal Section A-A

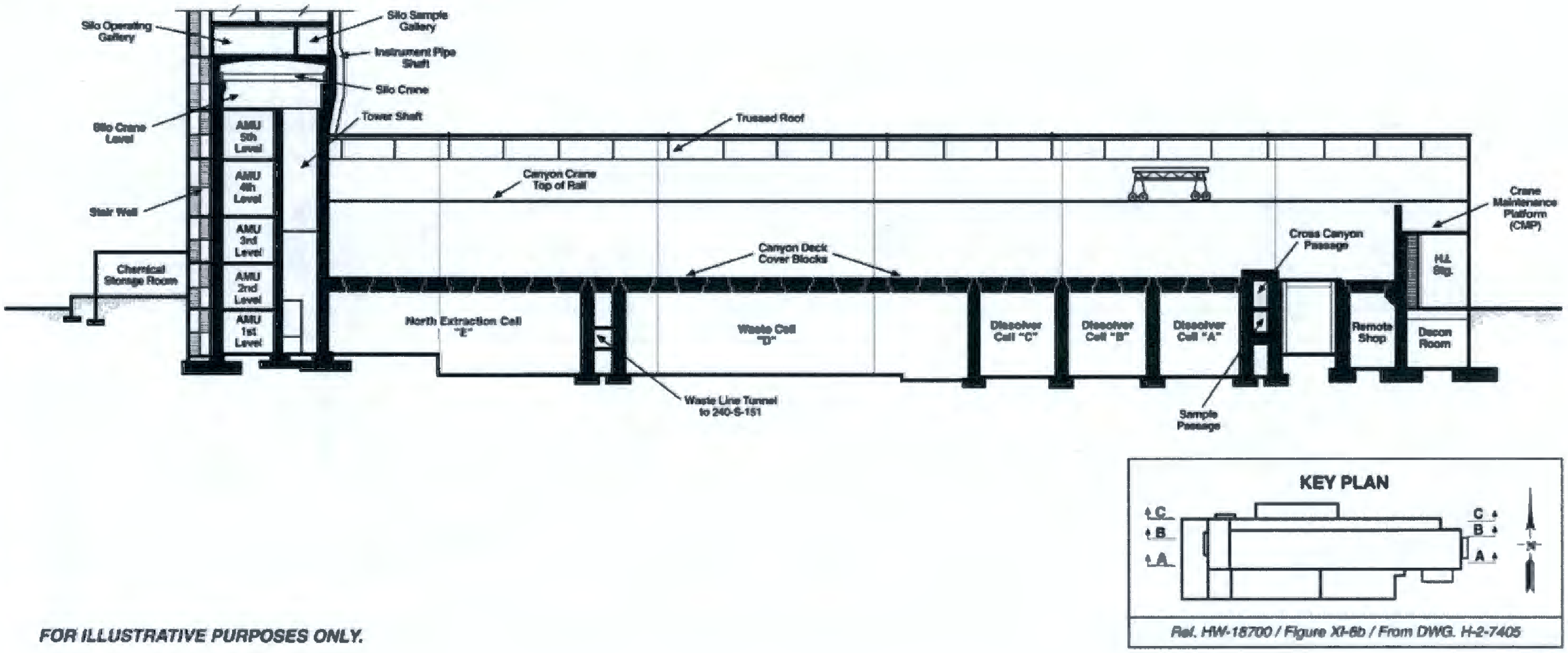


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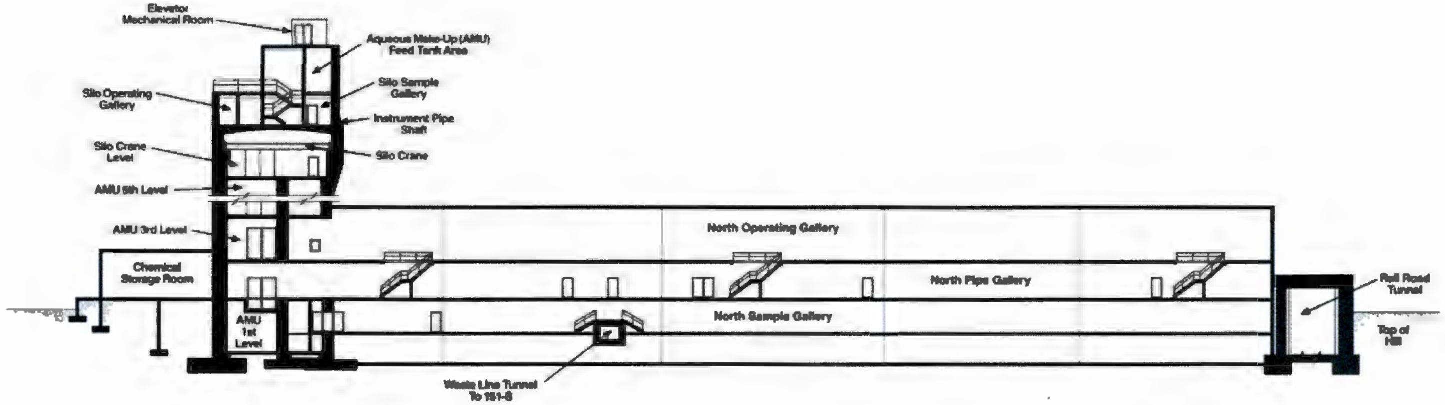
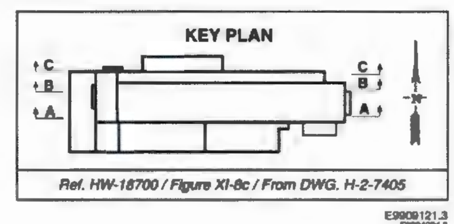
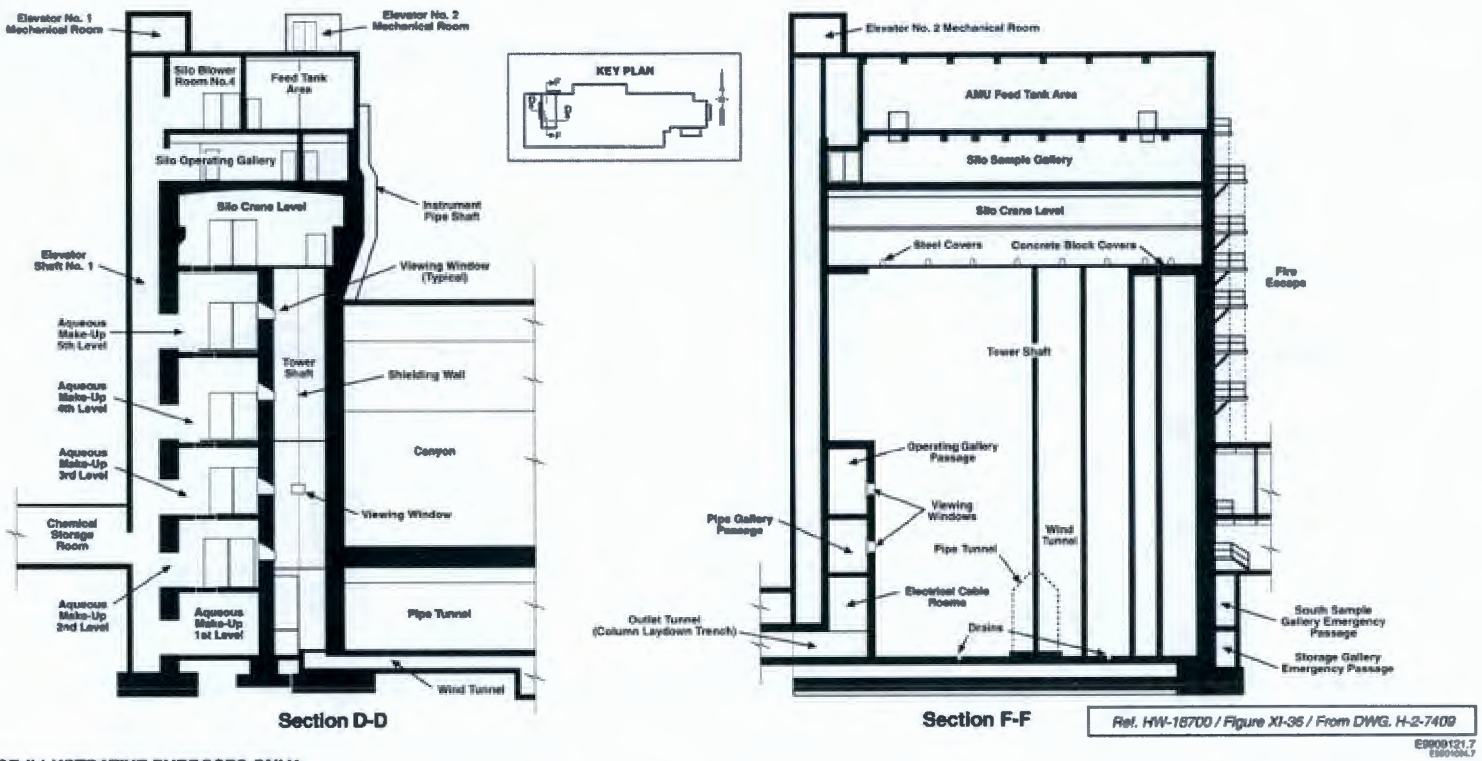
Figure 2-17. Longitudinal Section B-B





FOR ILLUSTRATIVE PURPOSES ONLY.

Figure 2-18. Longitudinal Section C-C



FOR ILLUSTRATIVE PURPOSES ONLY.

Figure 2-19. Silo Cross-Sections D-D and F-F

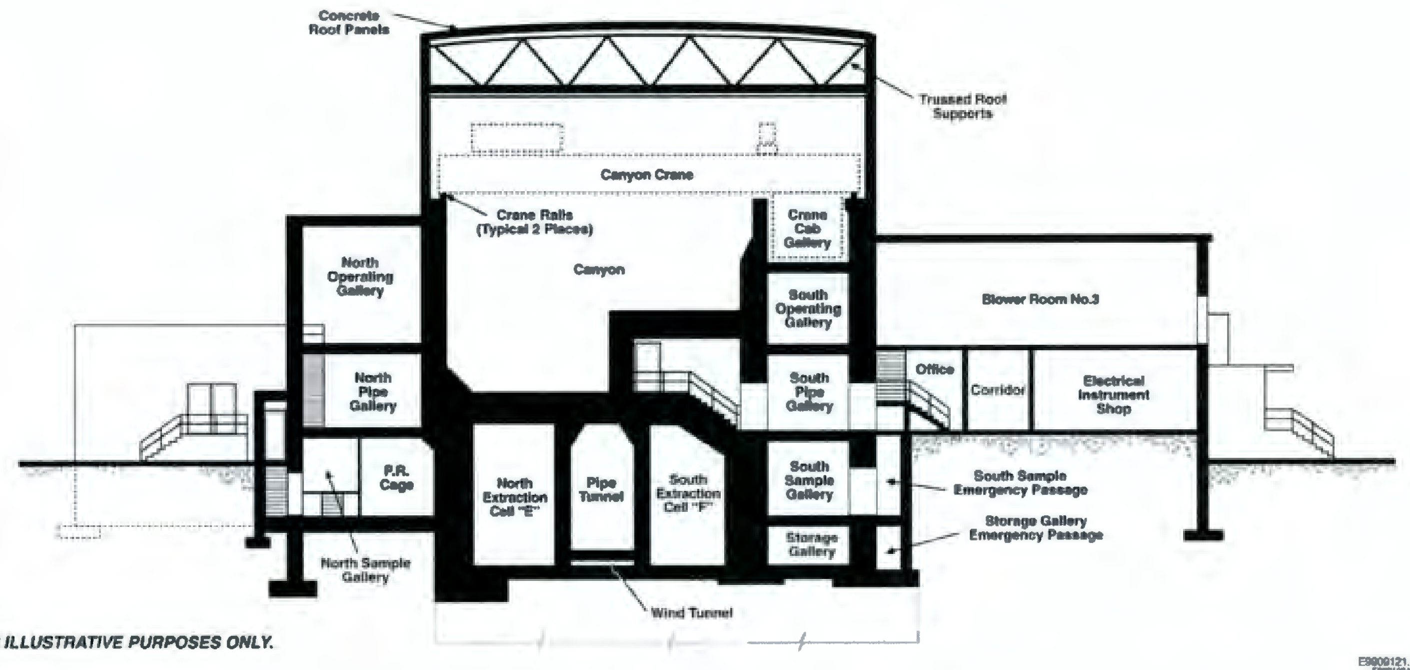


Figure 2-20. Canyon Emergency Exit

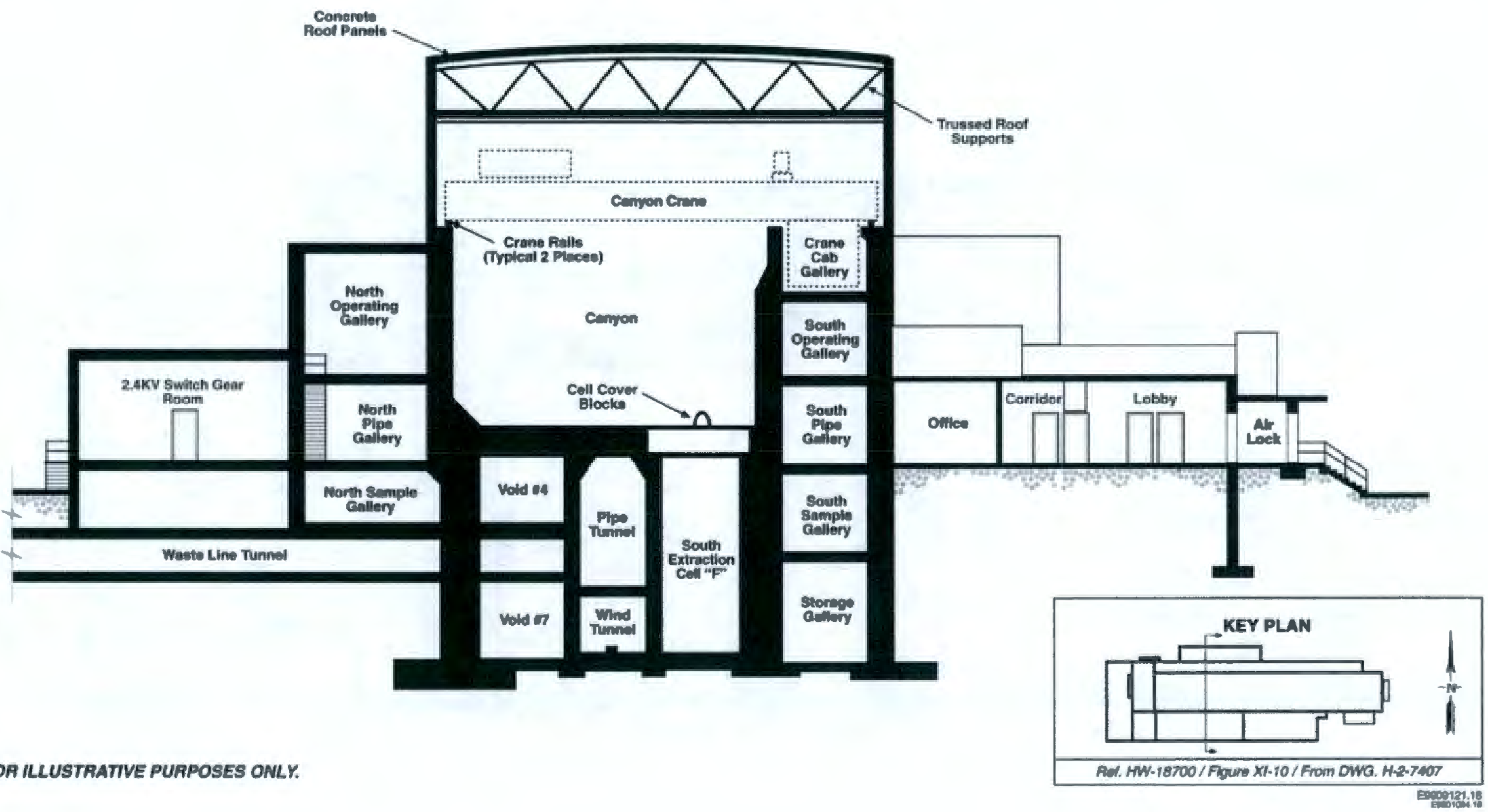
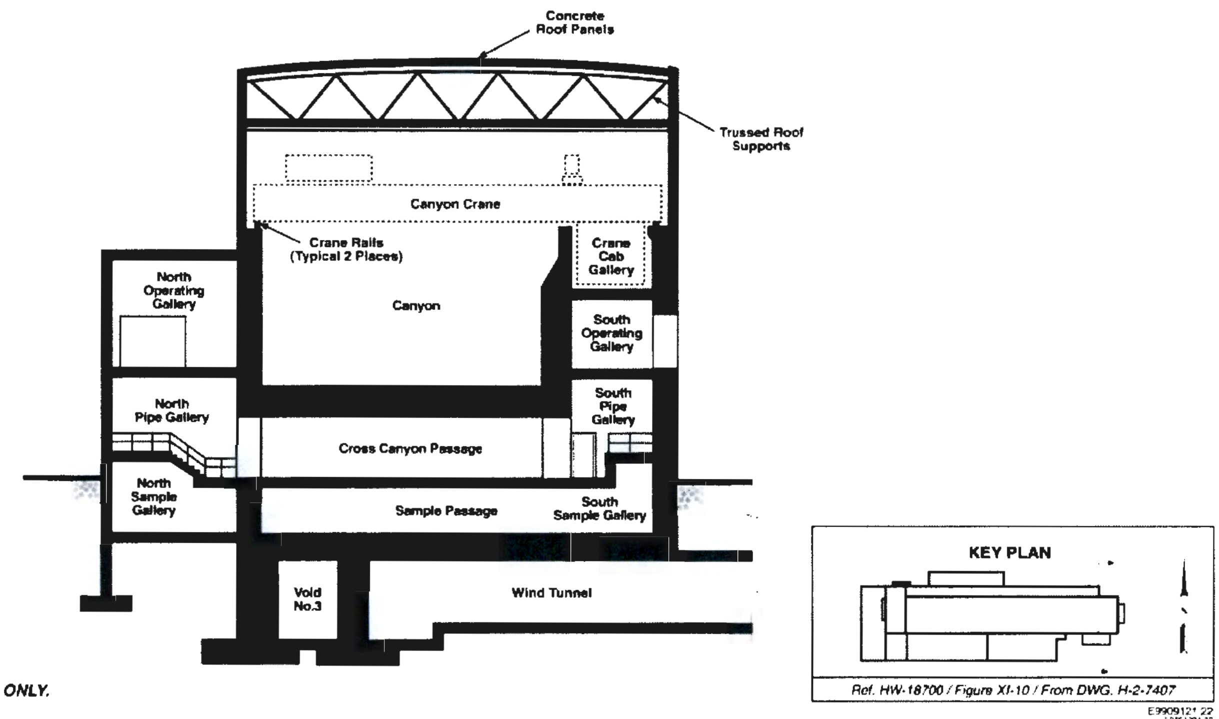


Figure 2-21. Waste Line Tunnel



FOR ILLUSTRATIVE PURPOSES ONLY.

Figure 2-22. Canyon Cross Passages

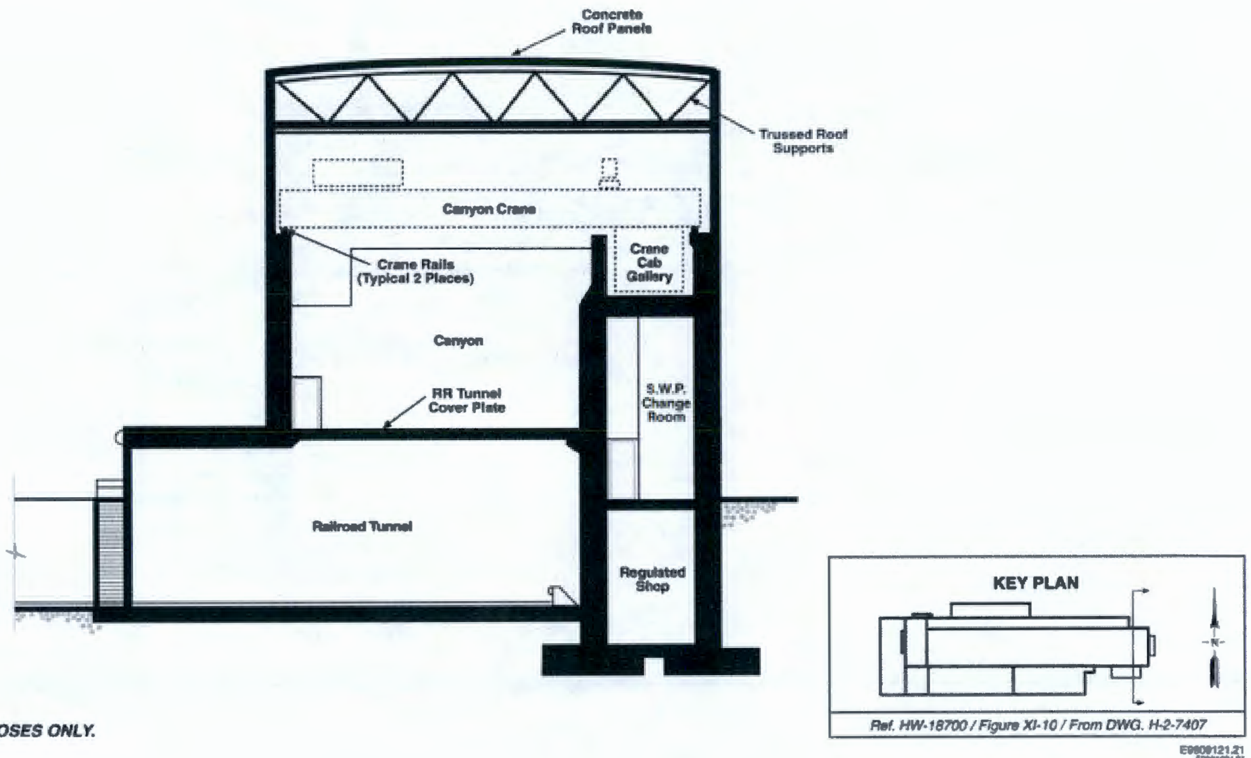


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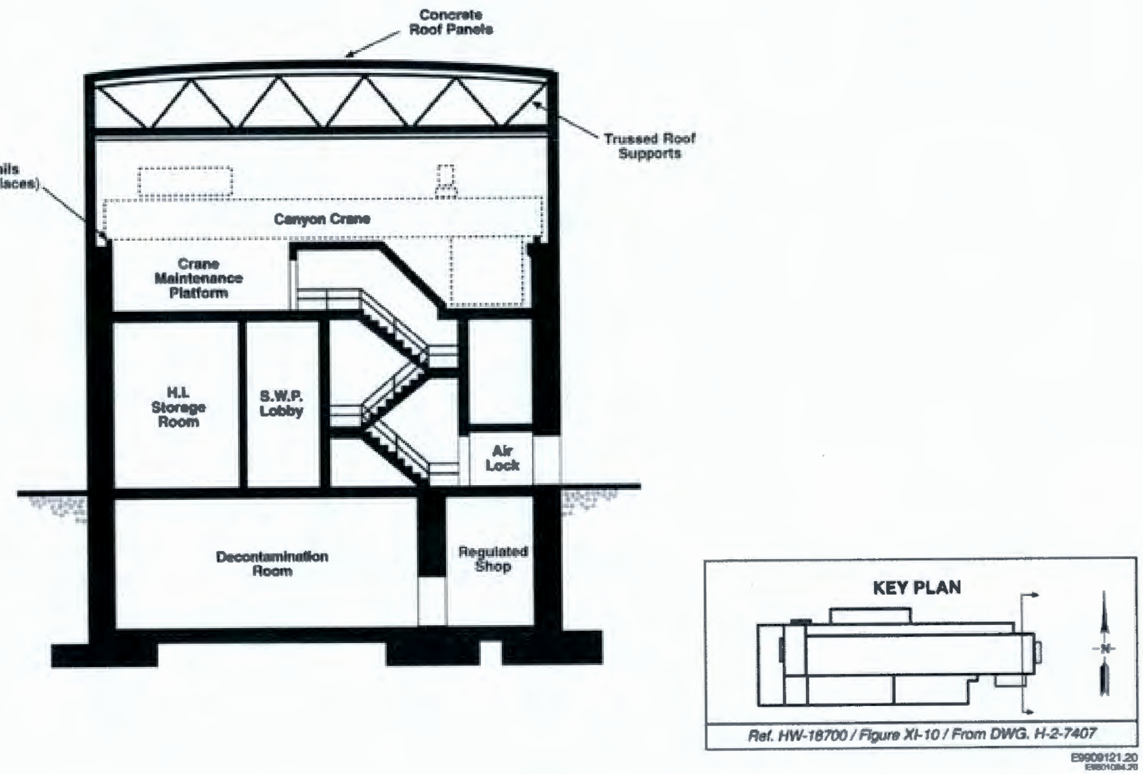
Figure 2-23. Railroad Tunnel



FOR ILLUSTRATIVE PURPOSES ONLY.

Figure 2-24. Crane Maintenance Platform

2.3.1 202-S Canyon Building

The 202-S Canyon Building is a reinforced-concrete structure consisting of the Canyon area, Galleries, Silo area, east end, and attached service areas. Figures 2-1 through 2-6 show general floor plans of the 202-S Canyon Building. The equipment arrangement is shown in Figure 2-5. Elevation schematics of the 202-S Canyon Building are shown in Figures 2-16 through 2-24. The building is 142 m (468 ft) long and 49 m (161 ft) wide. The Canyon area is 25.3 m (83 ft) high, with 18.3 m (60 ft) above grade. The Silo area is 40 m (132 ft) high, with 35.7 m (117 ft) above grade.

A limited qualitative structural evaluation of the REDOX Facility was performed in 1990 and documented in WHC-SD-DD-SA-001, *Qualitative Structural Evaluations of U-Plant and REDOX Buildings*. The REDOX structures evaluated were the Canyon Building and Silo. The evaluation was performed to assess the structure's capability to withstand high winds and earthquakes. The evaluation was based on the observations collected during walk downs and analyses of design data and limited failure modes. During the walk down of the Canyon Building, it was noted that the roof and sidewall of the building are flexible and, based on the type of intersection used, can move relative to each other. The intersection is a slip joint (i.e., paper joint) that could allow the building to open up during high winds or fail during an earthquake. The Silo was also evaluated. It was determined, based on the Silo's construction that it would survive the anticipated lateral loads associated with high winds and earthquakes.

2.3.1.1 202-S Canyon Cell Area

The Canyon area of the building originally contained fuel processing areas. Today the Canyon fuel processing areas contain deactivated equipment that was used for dissolution, separation, and decontamination of uranium and plutonium, as well as for waste concentration and neutralization, and solvent recovery. The Canyon area, which normally is not accessed under S&M, is defined as the process cells and cover blocks, deck, and overhead space. The Canyon area does not include the crane maintenance platform or the crane cab gallery. The Canyon area operated at high levels of radioactivity and was separated from the Canyon service areas by massive concrete shielding. The Canyon area is arranged in two parallel rows of process cells that run east and west separated by 0.6 m (2 ft) thick concrete walls for shielding. The nine cells of the Canyon are designated by letters, as follows:

- Cell A — dissolver cell
- Cell B — dissolver cell
- Cell C — dissolver cell
- Cell D — waste cell (treatment)
- Cell E — north extraction cell
- Cell F — south extraction cell
- Cell G — organic cell (recovery)
- Cell H — metal solution preparation cell
- Cell J — filter cell

Removable 1.2 m (4 ft) thick concrete process cell cover blocks form the Canyon deck above the cells. The cell cover blocks are stepped and tapered to eliminate a path for direct radiation streaming and skyshine.

The Canyon has two cranes. The largest is an electrically driven, overhead railway that operates on tracks running lengthwise on both sides of the Canyon. This crane has a 60 ton capacity main hoist, a 10 ton capacity rotating auxiliary hook, and two dual auxiliary hoists with capacities of 0.5 and 1 ton. The crane was used to remove cover blocks. The second crane has a 2 ton capacity, is electrically operated, and is mounted on a monorail running crosswise at the east end of the Canyon. This crane is used for servicing the main crane. Current electrical diagrams show power to the 60 ton Canyon crane only but it is not currently in service.

2.3.1.2 Galleries

Piping, operating, and sample galleries are located on the north and south sides of the Canyon. A storage gallery is located under the south sample gallery. The product receiver (PR) cage, which served as the plutonium loadout hood, is located in the north sample gallery. The PR cage (also known as the "Pu loadout hood" and the "plutonium loadout hood") and selected areas of the north sample gallery were stabilized with actions initiated in 1999 (BHI-01255, *Interim Characterization Report for the REDOX Plutonium Loadout Hood*, and 0200W-US-N0156-02, *Safety Evaluation for the Plutonium Loadout Hood Stabilization*). These stabilization activities eliminated known and suspected sources of radiological contamination. Routine surveillance of the north sample gallery may be reduced or discontinued if the area remains trouble free.

The stabilization activities initiated in 1999 consisted of stabilizing the PR cage, decontamination within the north sample gallery, stabilizing former process and waste lines and isolating the EF-8 exhaust system. The PR cage stabilization was accomplished by placing absorbent material in the sump of the PR hood, sealing the PR cage hood, and isolating the sampler hoods in the north sample gallery from the EF-8 exhaust system. These activities will prevent the inadvertent spread of contamination during S&M activities (e.g., surveillance). Figure 2-2 provides an illustration of the sample gallery level. Figure 2-7 provides an illustration of the PR cage where the sump is located (near the E-14 vessel).

2.3.1.3 202-S Silo

The Silo area, located at the west end of the Canyon, houses deactivated solvent-extraction columns and aqueous makeup vessels. The shaft, or tower process area, was designed specifically to house long extraction columns so that column solutions cascaded from one column to the next. Figure 2-19 shows cross-section views of the Silo, and Figures 2-8 through 2-15 show various plan views of the Silo. The Silo is 40.2 m (132 ft) high, 25.6 m (84 ft) long, and 12.5 m (41 ft) wide, and consists of former process and operating areas.

The fuel processing side of the Silo area was operated and maintained remotely and is separated from Silo service areas by concrete shielding. Solvent-extraction columns were removed from and brought into the facility through the column removal tunnel, located on the north side of the Silo near the column or tower shaft's floor. An electrically-driven railway crane with a 10 ton capacity is located in the Silo. The Silo crane has two auxiliary hoists rated at 0.5 and 1 ton capacities. No power is provided to the Silo crane.

The service/operating area of the Silo has eight levels. The first five levels are aqueous makeup unit (AMU) levels, the sixth level is occupied by the Silo crane, and the seventh level contains the Silo operating gallery and sample gallery. The eighth level houses Blower Room #4 and the feed tank area. One of the two Silo elevators is a freight elevator that served all levels of the Silo and chemical storage room; it is located on the west side of the building. The second elevator is on the north side of the building. Both elevators are out of service.

The column laydown trench is located outside the 202-S Canyon Building and is connected to the Silo via an underground tunnel. The trench is covered by diamond-plate steel and has a six layer asphalt pad beside it. The trench also has a weather cover. The columns were removed from the Silo shaft, placed in caissons, and loaded onto a transportation cart. The columns were then rolled to the other side of the tunnel. As a result of caisson and column removal activities, the laydown trench is highly contaminated. The number of remaining columns in the Silo shaft is uncertain. Current inventory assumptions bound the inventory. Future characterization activities will address this area.

The Silo's east-end segment contains the former hot shops for the facility and the railroad access tunnel to the Canyon processing area.

2.3.1.4 Service Areas

The north service area contains a 2.4 kV Switchgear Room, a wet-cell Battery Room, the North 480 V Switchgear Room, Blower Room #2, and the former electrical shop and office. Blower Room #2 contains a deactivated supply fan for the North Pipe and Operating Galleries. The electrical shop contains the MCC and lighting panel for the operating equipment in the REDOX Facility. The south and west service areas contain Blower Room #1; a Compressor Room; the South 480 V Switchgear Room, which contains deactivated MCCs; and former chemical storage, equipment, shop, and office areas. Blower Room #1 houses three deactivated supply fans for the REDOX Facility. The Compressor Room contains a deactivated air compressor and a deactivated instrument air dryer. There are no batteries remaining in the wet-cell Battery Room.

2.3.2 291-S Exhaust System

The 291-S exhaust system provides active confinement and treatment of radiological particulate before the exhaust is released to the environment. The system operates to filter the release under normal operations and to minimize the spread of contamination from the Canyon to gallery areas; however, no accident mitigation or prevention is credited in this DSA.

2.3.2.1 Wind Tunnel

The wind tunnel is a reinforced-concrete, below-grade structure that connects the 202-S Canyon Building (e.g., Silo shaft, Canyon cells, and the remote shop) to the 291-S exhaust stack.

2.3.2.2 Exhaust Fans

Exhaust fans EF-1 and EF-2 for the 202-S Canyon Building are located outside of the 291-S Building. Two stainless steel, direct-driven blowers are installed in parallel and are powered by 60-hp electric motors. The two fans are run alternately as required. The 291-S Building is not occupied, but is entered routinely for surveillance.

2.3.2.3 291-S Sand Filter

The 291-S sand filter removes radioactive particles from exhaust air before the air is discharged to the atmosphere. The sand filter is a below-grade structure, approximately 29.5 m (85 ft) by 29.5 m (85 ft) by 6.1 m (20 ft), consisting of approximately 2.0 m (6.5 ft) of sand and 3.4 m (11 ft) of air space in a concrete shell (H-2-8454). The filter medium decreases in particle size from coarse gravel, 2 to 3.5 in., at the bottom to 30-mesh sand at the top. The roof over the sand filter was repaired and is in good condition.

2.3.2.4 291-S-1 Operating Stack

The 291-S-1 Stack is 200 ft high above grade. It is constructed of reinforced concrete, with a free-standing stainless steel liner, which has a 45 in. inside diameter. The liner is capped at the top to cover the annulus between the stack and liner. A dished head, anchored to the base of the stack, is welded to the base of the liner. The stainless-steel inlet breeching is welded to the stack liner and enters the stack at a 45 degree angle.

Stack-gas sampling points are located at the top and bottom of the stack.

Spray rings are installed at three levels for washing down the inside of the liner. Condensate accumulation is drained from the stack liner and the annulus to the Drain Seal Tank, located in 292-S.

See HW-4317, *Outline Specification for the Concrete Ventilation Stack 291-S* for the complete specification.

The 291-S-1 stack is included in the Hanford Site Air Operating Permit for 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," and *Washington Administrative Code* 173-401, "Operating Permit Regulation." Under the *Hanford Site Air Operating Permit* (AOP 00-05-006), the Washington State Department of Ecology (Ecology) and Washington State Department of Health (WDOH) share responsibilities for oversight and compliance, with Ecology responsible for nonradioactive airborne emissions and the WDOH responsible for radioactive airborne emissions.

2.3.2.5 292-S Building

The 292-S Building was built as part of the original REDOX Facility and was the control point of discharge jets on dissolver vessels within Cells A, B, and C of the 202-S Canyon Building. The jets have been deactivated. An exhaust jet pit located directly beneath the building housed jets and actuators that controlled discharges from dissolver vessels and from the 291-S Building.

A second pit, located adjacent to the exhaust jet pit, is covered by exterior cover blocks. This 10.7 m (35 ft) deep pit contains the Drain Seal Tank (Tk-191) for vent lines from the 202-S Canyon Building and a sump that collects liquid from all vents and trenches in the 291-S, 292-S, and 293-S Buildings. Approximately 2.1 m (7 ft) of water remains in the pit. Before REDOX Facility operations ended, this liquid condensate remaining in the sump was air-jetted into the Drain Seal Tank and then jetted to D cell (waste cell) in the 202-S Canyon Building. Condensate from the 291-S-1 Stack Drains to the 292-S Drain Seal Tank (Tk-191). Adequate liquid level remains in the drain-seal tank to ensure isolation of each contributing drain and vent line. Due to the sources of this liquid, the liquid is assumed to have radioactive contaminants. Characterization is required before this liquid can be removed.

2.3.3 Auxiliary Systems and Support Facilities

The following sections describe a variety of facilities that were involved in waste generation, transfer, treatment, storage, or disposal.

2.3.3.1 276-S Solvent Handling Facility

The 276-S Solvent Handling Facility was used for bulk storage of pure hexone and chemical treatment of new and recycled hexone. Hexone was used in the extraction of plutonium and uranium from dissolved fuel elements (WHC-EP-0570, *The Distillation and Incineration of 132,000 Liters (35,000 Gallons) of Mixed-Waste Hexone Solvents from Hanford's REDOX Plant*). The building is located north and west of the 202-S Silo. This above-ground concrete building is approximately 13.1 m (43 ft) wide by 17.7 m (58 ft) long.

The building has two sections: the process section and service/operating section. The process section is 7.9 m (26 ft) wide by 17.7 m (58 ft) long with 0.6 m (2 ft) thick concrete walls on the south, east, and west sides. The north wall is constructed of a steel frame with corrugated asbestos siding. The process section housed three aluminum storage tanks used to treat and store hexone. Since deactivation and cleanup of the building in 1967, the hexone storage tanks in the 276-S Building process section have not been used. They were confirmed empty in 1989.

The service/operating section is 4.6 m (15 ft) wide by 17.7 m (58 ft) long and has a steel framework with asbestos siding on all four walls and the roof. A 0.6 m (2 ft) thick concrete wall with no interconnecting doors separates the process and operating sections. All doors from both sections open to the outside. Valves required for operation have extension handles that pass through the center concrete wall that separates the two sections.

Hexone storage tanks 276-S-141 and 276-S-142 are buried north of the 276-S Building. These single-shell, carbon-steel tanks have a capacity of 90,850 L (24,000 gal) each and were used to store makeup solvent for the REDOX Facility during operations. The residual sludge in the tanks from the distillation process was grouted as an interim closure in 2002 (BHI-01142, *REDOX Facility Safety Analysis Report*, and 0200W-US-N0217-02, *REDOX, Stabilization of Hexone Tanks*).

2.3.3.2 293-S Nitric Acid Recovery and Iodine Backup Building

The 293-S Nitric Acid Recovery and Iodine Backup Building provided filter backup capabilities for removing radioactive iodine in combination with recovering nitric acid vapors that developed when irradiated uranium rods were dissolved. This building was added to the REDOX Facility in 1957 and deactivated in 1969. The radioactive iodine was removed using a caustic scrubber system and the acid fumes were captured in a nitric acid absorber. The recovered nitric acid was stored in an underground, cylindrical, stainless steel, nitric acid storage tank (3 m [10 ft] high by 3 m [10 ft] in diameter) located directly west of the 293-S Building. The tank is empty.

2.3.3.3 2708-S Lagger Storage Building

The 2708-S Lagger Storage Building provided storage for lagging operations at the REDOX Facility. Inspection in 1999 found fluorescent light fixtures, loose metal shelving, and other small items remaining in the building. No significant sources of hazardous material are known or suspected. The building may have been mildly contaminated from events at the REDOX Facility.

2.3.3.4 2718-S Sand Filter Sample Building

The 2718-S Sand Filter Sample Building is a wooden structure with sampling ports that were used to monitor the quality of the exhaust air from the 291-S sand filter. The sand filter differential pressure gauge, which measured the pressure differential across the sand filter, is adjacent to this building. It has been downgraded to Less Than Hazard Category 3 using the methodology provided in CP-59461, 2015. The structure of the building is in poor condition and is scheduled for demolition in FY2016.

2.3.3.5 211-S Liquid Chemical Storage Tank Farm

Liquid chemicals used in the REDOX process were received and stored in the 211-S Tank Farm. The tank farm contains eight above-grade storage tanks with capacities ranging from 16,277 to 564,026 L (4,300 to 149,000 gal). The tanks were constructed of mild steel, stainless steel, or aluminum, depending on their contents. The 211-S Tank Farm was used to store nitric acid, sodium hydroxide, sodium dichromate, and aluminum nitrate nonhydrate. All tanks are empty at this time. No significant radiological inventory is associated with this tank farm.

2.3.3.6 2711-S Stack Gas Monitoring Building

The 2711-S Stack Gas Monitoring Building is a small wooden structure, 3.7 m (12 ft) by 4.3 m (14 ft) by 2.4 m (8 ft) high with a sloping roof. The building originally was used for gas monitoring and storing samples from the 291-S-1 stack. The building is being used to store equipment and has been downgraded to Less Than Hazard Category 3 using the methodology provided in CP-59461, 2015. The interior, exterior, and roof of the building are in poor condition and are scheduled for demolition in FY2016. The facility is deactivated; however, no quantitative estimate or assay of the residual radiological contamination exists.

2.3.3.7 2715-S Storage Building

The 2715-S Building is a steel-framed structure with metal walls and roof. It was used to store miscellaneous materials. The building is empty and contains no power sources or hazardous materials.

2.3.3.8 2904-SA Cooling Water Sampling Building

The 2904-SA Cooling Water Sampling Building was built in 1956 to provide sampling of process waste flowing from the 202-S Canyon Building through the 2904-S-170 weir to liquid waste disposal sites. The 2904-SA Building is a 2.4 m (8 ft) by 2.4 m (8 ft) by 2.4 m (8 ft) high prefabricated metal building that rests on a concrete foundation. The sampling equipment inside consists of a below-grade, 0.6 m (2 ft) by 0.9 m (3 ft) stainless steel tank, with a sample riser coming up through the building floor and associated piping. The sample building extends 0.9 m (3 ft) over the south end of the 2904-S-170 weir. The building is not active at this time. Radiological contamination is known to remain in the building and in deactivated equipment. The residual quantity has not been characterized, however, it was judged as minor contamination (DOE/RL-88-30, *Hanford Site Waste Management Units Report*). Consequently, this segment of the REDOX Facility is judged to contain less than HC-3 quantities.

2.3.3.9 2710-S Nitrogen Storage Building

The wood-framed 2710-S Nitrogen Storage Building originally was used to generate nitrogen gas for the REDOX Canyon vessels and is not being used. No significant radiological inventory is associated with the building. This building is scheduled for demolition in FY2016.

2.4 Structures, Systems, and Components

2.4.1 Ventilation System

Active confinement in the 202-S Canyon Building is provided by controlled airflow from areas of no or lesser contamination to areas of greater contamination. The motive force of the airflow is provided by the 291-S Exhaust System. Supply and ancillary exhaust systems have been deactivated. The following paragraphs describe the active confinement.

The 291-S-1 Flow Path provides the majority of ventilation for the 202-S Canyon Building and maintains the Canyon at a negative pressure with respect to the atmosphere. The galleries and other areas typically are maintained at a slight negative pressure with respect to atmosphere, thereby controlling the spread of contamination. The Silo is assumed to fall into the same ventilation area as the Canyon and the cells.

Operating at a nominal airflow rate of 566 m^3/min (20,000 ft^3/min), the building air is exchanged roughly once per hour (ventilated volume is approximately 28,320 m^3 [1,000,000 ft^3]). This exchange rate is lower than the normal exchange rate for operational nuclear facilities, but has proven adequate to address contamination control for this non-operational and non-occupied facility. The Canyon and cells have been maintained at these airflow rates for roughly 30 years without significant migration of contamination. Radiological surveys of surveillance areas and external areas that have followed loss of ventilation events have not found internal migration or external release of radiological contaminants. On these bases, the current operation of the 291-S ventilation system provides adequate radioactive material confinement during S&M operations.

The REDOX Facility is no longer an operating facility, and spills and releases into the Canyon and cell confinement spaces, as a result of process operations, no longer occur. During S&M activities, the likelihood of disturbing radiological material in the Canyon or cells is minimal, resulting in reduced challenges to the confinement function. Prior to any contamination area activity, standard radiological surveys are conducted to ensure personnel safety and to minimize the potential of air emissions.

2.4.1.1 202-S Canyon Building Ventilation Arrangement

The 202-S Canyon Building ventilation system, depicted in Figure 2-25, was divided into six zones with two different exhaust paths. The ventilation system has been modified extensively over the last 30 years. The original ventilation system relied on a number of supply and exhaust fans, the majority of which have been deactivated. Figure 2-25 mainly shows the supply fans in Blower Room #1, the exhaust fans at the 291-S Building, and the other exhaust stacks.

The current ventilation system relies on the operation of one 566 m^3/min (20,000 ft^3/min) exhaust fan (EF-1 or EF-2) to maintain appropriate negative differential pressures. All supply fans have been deactivated.

In addition to local indication and control functions, remote equipment monitoring and control are provided. The following remote monitoring and control capability is provided.

- Exhaust fans EF-1 and EF-2
  - Remote start/stop/indication

  - Remote vibration and temperature indication/alarm
- Remote differential pressure indication for the following:
  - Sand filter
  - Canyon to atmosphere
  - Canyon to sample gallery
  - Sample gallery to atmosphere
  - Wind tunnel to atmosphere

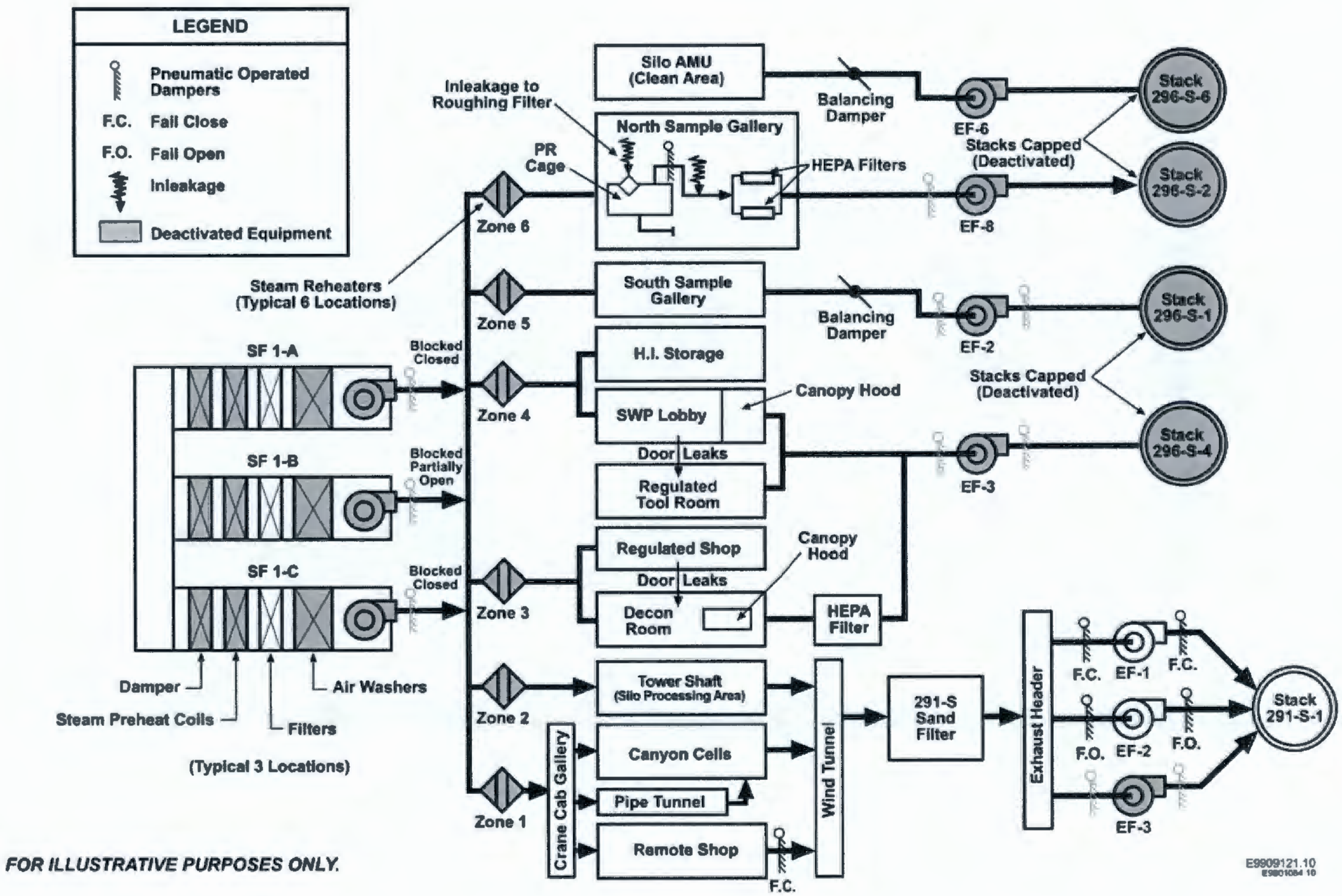


Figure 2-25. REDOX Facility Air Flow Diagram

2.4.1.2 202-S Canyon Building Ventilation Normal Operations

Blower Room #1 contains three supply fans that originally provided fresh air for the Canyon, Silo, sample galleries, and other areas. All three supply fans have been deactivated. The supply fan to the Canyon craneway, also located in Blower Room #1, has been deactivated as well.

The air-operated outlet dampers for all supply fans have been isolated from the plant air supply. Two supply fan outlet dampers are blocked in a closed position to increase negative differential pressures in the building and Canyon. To provide an infiltration flow path into the 202-S Canyon, Silo, and Sample Galleries, the outlet damper of one fan is blocked partially open. Supply air also is provided through other infiltration pathways, such as gaps around exterior doors in the service areas, the barn doors on the Silo tower area, the railroad tunnel door, and structural expansion joints.

Air exhausted from the 202-S Canyon Building is filtered by the 291-S Sand Filter before being discharged through the exhaust fans and 291-S-1 Stack. The fans discharge into a common plenum before discharging through the 291-S-1 Stack. A wind tunnel controller operates a pressure switch that can shut down either exhaust fan, if a minimum static pressure is not maintained in the wind tunnel. This function can also be bypassed. The inlet damper on EF-1 is provided with manual flow modulation to reduce system vibration if needed. Differential pressure is maintained at a nominal static pressure of approximately 1.3 cm (0.5 in.) wg with respect to the atmosphere.

The 291-S-1 Stack is equipped with a "stack pack" of generic Hanford Site design for effluent sampling and monitoring. The stack pack contains a record sampler, a sample flood controller and a pressure indicator. Since the stack is a minor stack and represents a very low risk of emissions to the environment, the sampler is operated periodically as required by the air operating permit.

2.4.1.3 202-S Canyon Building Ventilation Abnormal Operations

Exhaust fans EF-1 and EF-2 are operated alternately as required. There is no backup power for the exhaust fans and no automatic re-start capability.

2.4.1.4 Decreasing Wind Tunnel to Atmosphere Differential Pressure

The exhaust fans are controlled by the wind tunnel controller located in the south sample gallery. On decreasing wind tunnel-to-atmosphere differential pressure (e.g., failure of damper/motor coupler), the controller initiates a trip of either operating exhaust fan with no automatic start-up of the non-operating fan.

2.4.1.5 Loss of Air Supply

When EF-1 is operating, a high dP in the wind tunnel, indicating a loss of air supply, initiates the following actions:

- Trip EF-1
- Close EF-1 dampers and open EF-2 dampers

When EF-2 is operating and a high dP in the wind tunnel occurs, EF-2 will continue to operate.

2.4.2 Electrical Power, Lighting, and Communications

Electrical power is supplied to the REDOX Facility by two 13.8 kV lines, one of which supplies a 13.8 kV/480 V transformer that carries the majority of loads in the REDOX Facility. The other 13.8 kV line supplies a 13.8 kV/208/120 V transformer that supplies various lighting panels in the 202-S Canyon Building.

Figure 2-26 is a simplified one-line diagram of the electrical supply system and major loads. Power at the 202-S Canyon Building is fed from a 480 V MCC and various 208/120 V lighting panels. The 202-S Canyon Building provides power for the exhaust fan MCC, which is located in the 291-S Building.

Current electrical diagrams show the 60 ton Canyon crane as the only crane receiving power. Remote crane breaker operation is provided for the REDOX Facility. No power is provided to the Silo crane.

Communications for surveillance personnel are provided by radios and cellular telephones.

2.4.3 Compressed Air Systems

Compressed air is provided with a single compressor for ventilation damper control in the 291-S Facility.

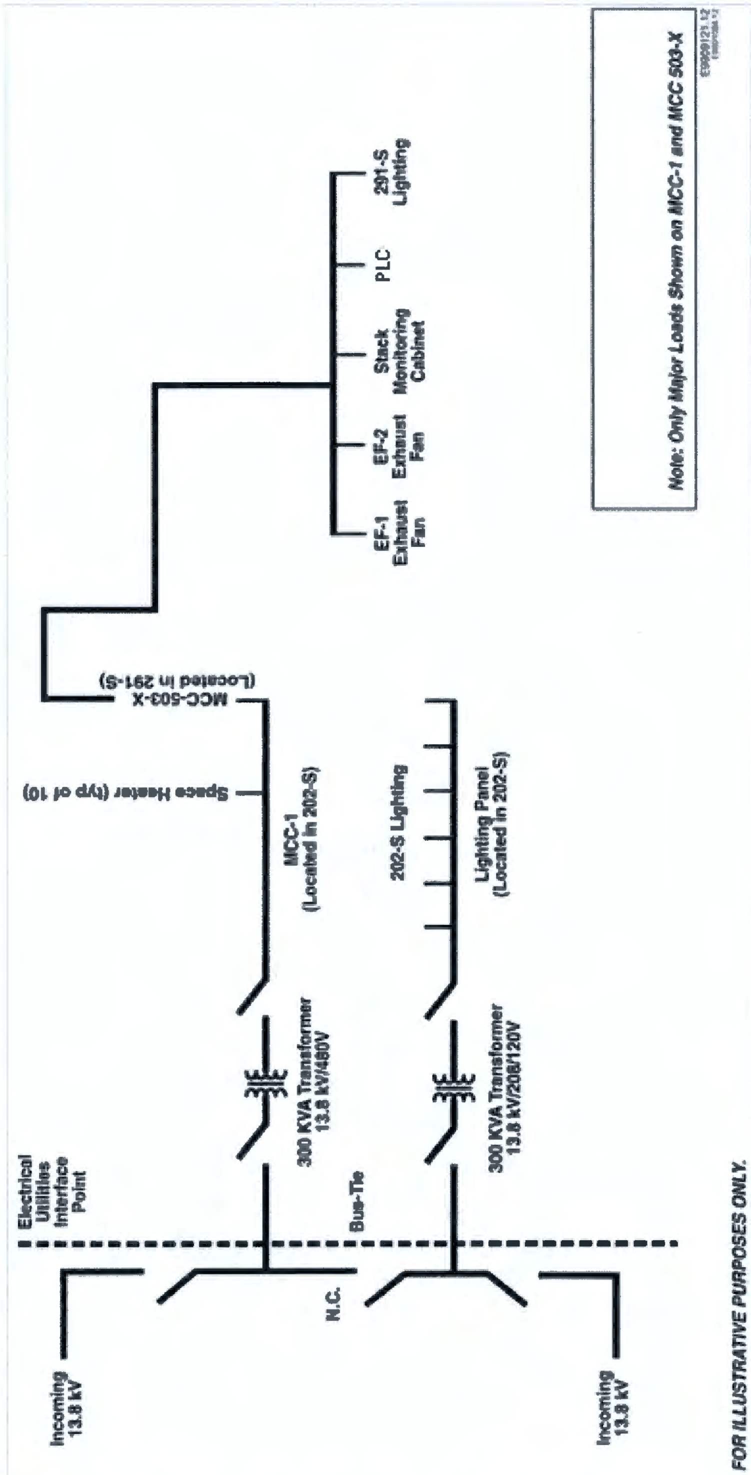


Figure 2-26. One-Line Electrical Schematic of REDOX Facility

2.4.4 Water Systems

Water supply within the 202-S Canyon Building has been isolated outside the building. A 50 cm (20 in.) raw water main and a parallel 30.5 cm (12 in.) sanitary water main are located on the west side of the REDOX Facility. From these mains, a 30.5 cm (12 in.) raw water line and a 15.2 cm (6 in.) sanitary line extend to the REDOX Facility north of the 202-S Canyon Building. The 15.2 cm (6 in.) sanitary line terminates in the yard; the 30.5 cm (12 in.) raw water line terminates at the exterior of the 202-S Canyon Building. A 30.5 cm (12 in.) raw water line and a 30.5 cm to 15.2 cm (12 in. to 6 in.) sanitary water line extend down the west and south sides of the facility, also terminating at the exterior of the 202-S Canyon Building. The sanitary water main and branch line supply hydrants in the yard can be used in manual firefighting.

2.4.5 Fire Protection Systems

The REDOX Fire Hazards Analysis (FHA), CP-45673, *Fire Hazards Analysis for REDOX Facility*, describes the fire protection systems in detail. The REDOX Facility has no wet or dry pipe sprinkler systems. Because the facility is not normally occupied, the 202-S Canyon Building contains no portable fire extinguishers. Five hydrants are supplied by the sanitary water system near the REDOX Facility and are located within 91 m (300 ft) of the building. The fire hydrants are located south and northwest of the building and provide adequate coverage. The water supplies from these hydrants are adequate for manual fire-fighting efforts. Fire department operational access to the facility is adequate.

As addressed in the FHA, the fire alarm system for REDOX was evaluated and deactivated as documented via issuance of *Hanford Fire Marshal Permit #2008-455*.

2.4.6 Equipment and Floor Drains

The REDOX Facility sumps and internal drains are plugged and not used. All process operations at the 202-S Canyon Building have been shut down for many years, and accumulations of liquid in equipment and floor drains are not subject to significant change. The equipment and floor drains of the 202-S Canyon Building do not have a significant accumulation of liquid. Connections to the sanitary sewer have been plugged.

At the 202-S Canyon Building, a number of process cell sumps and several deactivated process tanks have air-bubbler (weight-factor) level instruments installed. The level instruments can be utilized using a temporary compressed air source. According to plant personnel, no significant changes in level have occurred in the S&M mode. It is noted that readings from the Canyon cells may not give valid indications. It is believed that the liquid level is below the detection capability of the weight-factor level instruments. This cannot be verified because there is no capability for cell entries in the S&M mode.

Condensate forming in the 291-S-1 stack drains to the 292-S Drain Seal Tank (Tk-191) (see Section 2.3.2.5). Other liquid waste is disposed of in accordance with established procedures.

Chapter 3.0

Hazard and Accident Analysis

Contents

Tables

3.0 Hazard and Accident Analysis

3.1 Summary of Remaining Hazards

Inventories of hazardous substances, radiological material, and hazardous material were removed as part of the deactivation efforts. The remaining materials consist of residual contaminants that remain after flushing, draining, and other inventory-reduction activities, and contamination that remains in the exhaust system, primarily in the sand filter. No process material or chemical stocks remain. The only chemicals that are introduced are those associated with decontamination, stabilization, and pest control. The following sections summarize the remaining residual radiological and hazardous materials.

3.1.1 Radioactive Materials Inventory

The majority of the radiological inventory at the REDOX Facility is located in the 202-S Canyon Building and in the 291-S Exhaust System Sand Filter. Relatively minor quantities are located in other buildings, typically as residues or surface contamination. Table 3-1 lists the inventories for the 202-S Canyon Building, north sample gallery, and sand filter. Table 3-2 provides the initial hazard categorization summary. The values in Table 3-1 are based on the best available data. For radiological consequence calculation purposes, the alpha activity is assumed to be ^{239}Pu and the beta activity is assumed to be ^{90}Sr. These assumptions are conservative in that ^{239}Pu and ^{90}Sr have the largest dose conversion factors (DCFs) of the radionuclides potentially present in significant quantities.

Table 3-1. REDOX Facility Radiological Inventory

Facility	Inventory/Location	Source Document	Remarks
202-S Canyon Building, Silo, railroad tunnel and process cells, piping, equipment and ancillaries	1,500 Ci alpha 9,000 Ci beta	SD-DD-FL-001	Based on historical published data, the basis of which is unknown. Based on review of deactivation records (FH-0400890) the distribution of the residual contamination in the Canyon process area is approximately 46% in vessel piping, 44% surface contamination in Canyon cells, and 10% surface contamination in the Silo and column laydown trench. Conservative assumption is that all alpha is ^{239}Pu and all fission products are bounded by beta assumed as ^{90}Sr.
202-S North Sample Gallery	140 Ci of alpha 840 Ci of beta	BHI-00994	Inventory basis as established in BHI-01142. Conservative assumption is that all alpha is ^{239}Pu and all fission products are bounded by beta assumed as ^{90}Sr.

Table 3-1. REDOX Facility Radiological Inventory

Facility	Inventory/Location	Source Document	Remarks
291-S sand filter	340 Ci alpha 8,000 Ci beta	0200W-CA-N0007	Estimated inventory based on stack emission data and assumed sand filter efficiency of 99.95%. Conservative assumption is that all alpha is ^{239}Pu and all fission products are bounded by beta assumed as ^{90}Sr.

Notes:

BHI-00994, *In-Situ Non-Destructive Radiological Characterization of Selected 202-S Reduction Oxidation (REDOX) Facility Sample Gallery Pipes and Vessels*

FH-0400890, *REDOX Facility Safety Analysis Report Addendum Submittal*

SD-DD-FL-001, *Rockwell Retired Contaminated Facility Listing and Description*

0200W-CA-N0007, *291-S Sand Filter Loading Estimate*

Table 3-2. Initial Hazard Categorization Summary

Isotope	Activity (Ci)	Specific Activity (Ci/g)	Mass (g)	Cat 2 Threshold Value (g)	Cat 2 Mass Ratio	Cat 3 Threshold Value (g)	Cat 3 Mass Ratio
202-S Canyon and Ancillary Buildings							
^{90}Sr	9.00E+03	1.37E+02	6.59E+01	1.60E+02	4.12E-01	1.20E-01	5.49E+02
^{239}Pu	1.50E+03	6.21E-02	2.42E+04	4.50E+02	5.38E+01	8.40E+00	2.88E+03
North Sample Gallery							
^{90}Sr	8.40E+02	1.37E+02	6.15E+00	1.60E+02	3.85E-02	1.20E-01	5.13E+01
^{239}Pu	1.40E+02	6.21E-02	2.26E+03	4.50E+02	5.02E+00	8.40E+00	2.69E+02
291-S Exhaust System							
^{90}Sr	8.00E+03	1.37E+02	5.86E+01	1.60E+02	3.66E-01	1.20E-01	4.88E+02
^{239}Pu	3.40E+02	6.21E-02	5.48E+03	4.50E+02	1.22E+01	8.40E+00	6.52E+02
				Sum of Ratios	7.10E+01		4.89E+03

Notes:

Specific activities taken from RADIDOSE. Hazard Category thresholds taken from DOE-STD-1027-92.

In general, detailed radionuclide characterization data (i.e., form, quantity, and location) for the 202-S Canyon Building do not exist. The values listed in Table 3-1 are based on best available information. Surveys (BHI-00994) have identified significant accumulations of residual materials in the north sample gallery, located primarily in PR cage processing equipment. Evaluation (0200W-US-N0156-02) of characterization (BHI-01255) of the PR cage confirmed the plutonium inventory estimates presented in BHI-00994 and showed that nearly the entire inventory is contained within the processing equipment. BHI-01255 also confirmed earlier indications (BHI-00994) that ^{241}Am and ^{237}Np are present in the PR cage. However, the likelihood that other vessels and piping associated with the PR cage contain significant fissionable inventories is low. Because of the extensive chemical cleaning of the process vessels and piping followed by weekly flushing with water (ISO-1108), the radioactive material remaining in these confinement systems likely is encrusted and fixed to the internal surfaces and not easily dislodged. The balance of the radioactive material is assumed to be loose surface contamination distributed throughout the structure.

The inventory of radioactive materials has a very high degree of uncertainty as to form, quantity, and distribution. Because of this uncertainty, highly conservative assumptions are used when applying the limited inventory data. In any undertaking that involves intrusive activities into the REDOX Facility, caution must be exercised, recognizing that higher-than-predicted levels of contamination or materials may be encountered.

3.1.2 Hazardous Chemical and Toxic Material Inventory

Exposure to hazardous chemicals at the REDOX Facility was rated as "low to negligible" in WHC-EP-0619, *Risk Management Study for the Retired Hanford Site Facilities*. The study identified containerized chemicals in various locations, lead shielding and counterweights, deteriorating and flaking lead-based paints, mercury switches, fluid-filled manometers inside facility buildings and on the surrounding grounds and other small quantity residuals.

The REDOX Facility used large amounts of the following hazardous chemicals:

- Acetylene tetrabromide
- Methyl isobutyl ketone (Hexone)
- Nitric acid
- Sodium nitrate
- Sodium hydroxide
- Coating and caulking compounds
- Zirconium cladding material
- Ammonium fluoride/ammonium nitrate
- Tributyl phosphate
- Normal paraffin hydrocarbon (kerosene)

While deactivation activities removed the vast majority of these chemicals, minor quantities of residual chemicals are expected to be found in the process vessels and piping located in the buildings throughout the facility. Deactivation procedures specified the use of nitric acid, permanganate, and oxalic acid that also are likely to be present in residual quantities.

In addition to residual quantities of process and deactivation chemicals, polychlorinated biphenyl light ballasts, lead paint, lead material used for shielding, mercury in switches and lights, used oils and other small quantity residuals may be encountered during the conduct of S&M activities.

Asbestos-insulated steam lines run throughout the REDOX Facility. Asbestos also was used as a building material in the walls in the operating area of the 276-S Solvent Handling Building.

3.1.3 Industrial Hazards

The REDOX Facility is in S&M mode and is not normally occupied. Entries to the building are done for inspections, maintenance activities, and other activities described in Section 2. Industrial hazards associated with these entries are the hazards associated with entry to any large industrial facility that is not normally occupied. Hazards associated are mitigated by the SMPs described in Chapter 5.0.

3.2 Nuclear Facility Hazard Classification

3.2.1 Hazard Category

The REDOX Facility is considered a HC-2 nuclear facility based on the quantity, form, and location of the radioactive material. No consideration is given to adjusting the initial HC that is summarized in Table 3-2. Uncertainty related to the lack of documented characterization precludes adjusting the release fraction to reduce the HC. Until characterization is complete, the facility shall remain a HC-2 nuclear facility.

The REDOX Canyon, north sample gallery, and the exhaust system contain the significant inventories of the residual radiological contamination. Consequently, the 202-S Canyon Building and the 291-S Exhaust System (exhaust tunnel, sand filter, and stack and condensate ancillary) are treated as a single segment for hazard classification purposes. Other segments of the REDOX Facility that are considered HC-3 or greater include TRU waste staging areas and selected ancillary structures. A listing of the facility segments that are less than and greater than HC-3 are provided in Table 2-1.

3.2.2 Criticality

In accordance with the requirements of HNF-7098, *Criticality Safety Program*, the REDOX Facility is classified as a limited-control facility because the contents may contain greater than half of a minimum critical mass, but a criticality is determined to be incredible in HNF-36331 where fissionable material is not disturbed. For activities affecting the form/distribution of the fissile material, a criticality is judged to be incredible per CHPRC-02595.

3.3 Hazard Analysis

The original hazard identification and hazard analyses prepared by Bechtel Hanford, Inc. are contained in BHI-01142. Subsequent USQ determinations, contractual requirements, and directions by DOE (03-ABD-0066) provided revisions to the original conclusions. The original hazard analysis was updated to reflect the directed risk evaluation guidelines and to reflect CHPRC's applicable SMPs (Appendix A, Table A-3). This section presents the methodology and results of the REDOX Facility hazard analysis. The analysis is a structured, systematic examination of the facilities and operations described in Chapter 2.0. The hazard analysis consists of a hazard identification and evaluation. The Hazard Analysis is intended to meet the guidance and/or requirements of the following documents:

- DOE-STD-1027-92,
- DOE-STD-1120-2005,

Completing the Hazard Analysis, analyzing the accidents, and developing this document consistent with the guidance and/or requirements of DOE-STD-1120-2005 provides compliance with the expectations of 10 CFR 830, "Nuclear Safety Management."

3.3.1 Hazard Identification

The hazards identification checklist and energy verification prepared by CHPRC to verify the Bechtel Hanford, Inc. analysis is found in Appendix A, Table A-1.

The hazards identification table is found in Appendix A, Table A-2. Table A-2 further presents the hazard type, location, form, quantity, remarks, and reference to where the information was found. The following types of hazards were investigated:

Radioactive material	Direct radiation	Fissionable material
Hazardous material	Biohazards	Flammable/combustible material
Reactive material	Electrical energy	Thermal energy
Kinetic energy	High pressure	

3.3.2 Hazards Analysis

The REDOX Facility Hazards Analysis was conducted using a graded approach. The preliminary hazards evaluation table is found in Appendix A, Table A-3. Table A-3 presents the potential event, location, hazard type, impact of the event, possible cause, SSCs and administrative features that might serve a preventive or mitigative function, consequences, likelihood ranking, risk values, and a Facility Worker (FW) discussion. The evaluation was performed by first postulating an event involving a specific hazard (e.g., fissionable material) at a specific location (e.g., Canyon area). Evaluated events fall into one of three general categories: natural phenomena (e.g., seismic event or high wind), external events (e.g., aircraft impact or water intrusion), and internal/operational events (e.g., fire or criticality).

The SSCs and administrative controls (ACs) that would serve to prevent or mitigate the event then were identified. Controls were identified primarily based on a review of available facility and operations documentation and by consulting experienced facility personnel at the hazard evaluation workshop that was performed for this update.

The final two columns of Table A-3 address the hazards posed to the FW.

The frequency and consequence categories used by the hazards analysis team are presented in Tables 3-3 and 3-4 as required by PRC-PRO-NS-700. Consequence ranking, likelihood ranking, and risk values are unmitigated values.

Table 3-3. Frequency Categories Used in the Hazards Analysis

Estimated Annual Frequency	Description: Based on the initiating event(s) postulated
Anticipated: 10-2/yr to < 10+0/yr	The hazardous condition has occurred or is likely to occur during the lifetime of the facility.
Unlikely: 10-4/yr to < 10-2/yr	The hazardous condition is foreseeable, but unlikely to occur during the lifetime of the facility.
Extremely Unlikely: 10-6/yr to < 10-4/yr	The hazardous condition is perhaps possible, but extremely unlikely to occur during the lifetime of the facility.
Beyond Extremely Unlikely: < 10-6/yr	The hazardous condition is considered too improbable to warrant further consideration.

Table 3-4. Safety Consequence Assessment Codes Used in the Hazards Analysis

Consequence Level	Maximally-Exposed Offsite Individual [a]	Collocated Worker [b]	Facility Worker [c]
High	Considerable offsite impact on people or the environs Challenge 25 rem TED[d]	Significant onsite impact on people or the environs ≥100 rem TED	For SS designation, consequence levels such as prompt death, serious injury, or significant radiological or chemical exposure must be considered.
Moderate	Only minor off-site impact on people or the environs ≥1 rem TED	Considerable on-site impact on people or the environs. ≥25 rem TED	No distinguishable threshold. <High consequence. Treat as "Low" consequence.
Low	Negligible off-site impact on people or environs <1 rem TED	Minor on-site impact on people or the environs <25 rem TED	No distinguishable threshold. <High consequence

Notes:

[a] Offsite public: The offsite public is represented by the MOI, a hypothetical receptor located at or beyond the Hanford Site boundary at the distance and in the direction from the point of release at which maximum dose occurs. RL has also requested that doses be provided for Highway 240 for information purposes to assess impacts to members of the public that may be within the Hanford Site boundary.

[b] Collocated Worker: The CW is represented by a hypothetical onsite receptor located at a distance of 100 m from the point of release at which the dose occurs.

[c] Facility Worker: An individual who is impacted by an accident and who is located within the facility boundary.

[d] Total Effective Dose (TED)

Using the scenario frequency and consequence categories assigned by the hazards analysis team, the overall scenario risk is determined by the values found in Table 3-5. Those scenarios identified as risk bin I, II, or III in overall risk are candidates for quantitative consequence analysis as design-basis accidents.

Table 3-5. Risk Bin Values

Consequence	Beyond Extremely Unlikely Below 10^{-6}/yr	Extremely Unlikely $10^{-4} – 10^{-6}$/yr	Unlikely $10^{-2} – 10^{-4}$/yr	Anticipated Above 10^{-2}/yr
High	III	II	I	I
Moderate	IV	III	II	II
Low	IV	IV	III	III

3.3.3 Hazards Evaluation

The hazard evaluations are documented in Appendix A, Table A-3. Part of the hazard evaluation was a selection process to determine which hazards would be examined further. Hazard events were selected for further evaluation to define bounding and representative consequences and to ensure that appropriate controls are defined. The following events were selected for further evaluation:

- **Seismic Event**. A seismic event affecting the 202-S Canyon Building and 291-S Sand Filter was evaluated in the Preliminary Hazard Evaluation Tables in Appendix A. The assigned consequence rank is low to the CW and the likelihood rank is unlikely. The seismic event is assumed to result in a failure of the 202-S Canyon Building structure, stack, and 291-S Sand Filter. For this type of event, the entire inventory of the 202-S Canyon Building, including the North Sample Gallery, is affected, along with the entire inventory of the Sand Filter. An accident analysis is provided in Section 3.4.1 to define the residual risk and applicable controls for the unlikely seismic event.

- **PR Cage Fire**. Viewing panels that enclose the PR Cage in the north sample gallery provide a combustion hazard to the residual contamination. A fire involving the combustion loading of the PR cage was evaluated in the hazard evaluation (Appendix A, Table A-3) and the FHA (CP-45673). The FHA concludes that no potential exists for significant damage to the Canyon SSCs and no impact to the exhaust ventilation is anticipated. The potential fire event assigned consequence rank is low and the frequency is anticipated. The event is analyzed further in Section 3.4.2.

- **Silo Fire**. Oil-filled viewing windows in the REDOX Silo area have the capacity of approximately 11,870 L (3,137 gal) of mineral oil. A fire involving potential transient and fixed combustion loading of the REDOX Silo was evaluated in the hazard evaluation (Appendix A, Table A-3) and the FHA (CP-45673). The FHA concludes that no potential exists for significant damage to the Silo's SSCs and no impact to the exhaust ventilation is anticipated. The hazard evaluation (Appendix A, Table A-3) judges the potential fire event to be a consequence rank of low and a frequency rank of anticipated. The Silo fire is further analyzed in Section 3.4.3, and in FH-0400890. The analyzed Silo fire burns the contents of multiple, mineral oil-filled windows and propagates into the tower shaft, resulting in a lower frequency rank of unlikely.

- **Canyon Load Drop**. The Canyon crane is not used routinely, however, demands may arise, as they have in previous years of S&M, for its capacities. Mechanical and operational errors are anticipated initiators for events related to load drops in the 202-S Canyon Building. The accident is assigned a consequence rank of low and a frequency rank of anticipated. Section 3.4.4 presents the accident analysis and applicable risk evaluation that is representative of load drops in the Canyon building.
- **Sand Filter Load Drop**. Anticipated maintenance activities may require lifting loads around the facility. The inventory of the sand filter was selected as the worst case inventory of the REDOX Facilities outside of the Canyon. The accident is assigned a consequence rank of low and a frequency rank of anticipated. An accidental load drop onto the sand filter is analyzed in Section 3.4.5 as the bounding accident of impact events that may occur outside the REDOX Facility.
- **Waste Staging Fire**. Risk reduction activities may require removal and disposal of contaminated equipment before final decommissioning. Provisions for staging these types of waste and typical contamination control waste are necessary. The accident is assigned a consequence rank of low and a frequency rank of anticipated. Section 3.4.6 provides accident analysis of potential waste staging needs to verify appropriate control requirements. This fire is identified as the Maximum Possible Fire Loss (MPFL) in the REDOX FHA.
- **Internal Equipment Deflagration**. Risk reduction activities may require removal and disposal of contaminated equipment before final decommissioning. Out of service process equipment may potentially contain a flammable atmosphere inside. Controls for protecting the FW from an inadvertent deflagration when performing intrusive operations are necessary. Section 3.4.7 provides the accident analysis of potential internal equipment deflagrations.
- **Aircraft Impact Event**. An aircraft (i.e., missile) impact into the REDOX facility structure can cause a local response or damage at the point of contact. For concrete structures, this local response or damage is characterized as penetration and spalling, scabbing, punching shear, and perforation of building structural components (e.g., a wall or floor) that may not result in the overall failure or collapse of the whole building structure. Section 3.4.8 provides accident analysis of an Aircraft Impact Event using guidance in accordance with STD-3014-2006.

3.4 Accident Analysis

The potential dose consequences of the selected accident analyses are determined using RADIDOSE, Version 3.0, a dose consequence program for the Hanford Site. For each accident scenario, airborne release fractions and respirable fractions were determined using either DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities,* or PRC-STD-NS-8739. The potential dose was then determined using RADIDOSE for the Hanford Site. The material form of the inventory was modeled as generally soluble and the International Commission on Radiological Protection (ICRP) -68, *Dose*

Coefficients for Intakes of Radionuclides by Workers: A Replacement of ICRP Publication 61, and ICRP-72, *Age Dependent Doses to Members of the Public from Intake of Radionuclides, Part 5, Compilation of Ingestion and Inhalation Coefficients,* DCFs were used. The default values for breathing rate, emission source type, and release duration given in RADIDOSE were used in evaluating the dose consequences. The RADIDOSE analysis results are presented in Appendix D. Dose is reported as TED.

The maximum onsite receptor is evaluated at 100 m (328 ft). The maximum calculated dose for the onsite public was evaluated at Highway 240 at a distance of 4.3 km (2.7 mi). The nearest site boundary is 12,580 m (7.8 mi) to the south and was used as the minimum distance to the MOI. Distances were taken from Hanford Map, Version 2.0.

The atmospheric dispersion factor, χ/Q, accounts for the effects of atmospheric dispersion of material released under postulated accident conditions at a specified receptor location. It is defined as the concentration in air per unit release rate of the material from an upwind source at a particular receptor location. The value of χ/Q is a function of the type of release (elevated, buoyant, ground level, etc.), release duration, wind speed, atmospheric stability class, and distance from the source (only centerline or under-centerline, ground-level values are considered).

As indicated in DOE-STD-3009-2014, and OE-3: 2015-02, *Atmospheric Dispersion Parameter (χ/Q) for Calculation of Co-located Worker Dose*, a χ/Q value of 3.5E-03 sec/m^3 is used for a ground-level release evaluation at the 100 m receptor location (CW). However, this value is not appropriate for operations not conducted within a physical structure. Events that occur outside of the physical structure, such as the outside waste handling events, use the default RADIDOSE χ/Q.

Copies of the output sheets from RADIDOSE calculations for the applicable accident analyses are attached in Appendix D. The onsite public receptor dose consequences were all determined to be in the millirem range and, therefore, did not provide any additional information for consideration and identification of controls. Therefore, these values are captured in the RADIDOSE calculations in Appendix D, but not reported in Chapter 3.0 of this DSA.

3.4.1 Seismic Event

This is a natural phenomenon event involving an earthquake that impacts the 202-S Building and the 291-S Sand Filter. For this scenario, a seismic event is assumed to cause simultaneous total failure of the 202-S Canyon Building structure and the 291-S Sand Filter, with resulting ground level release of material.

3.4.1.1 Scenario Development

Being that there are two components to the accident with significantly different physical characteristics, these events are treated separately and their individual consequences are added to represent the seismic event.

3.4.1.1.1 Scenario Development for 202-S Building

A previous structural study of the 202-S Canyon Building concluded that the building could withstand seismic events up to a peak ground acceleration of 0.03 g (WHC-SD-DD-SA-001).

The likely failure mode of the building would be a collapse of the roof into the Canyon area. A structural analysis (0200W-CA-C0027, *Load Drop Evaluation of 202-S Canyon Roof Structure*) determined that the blocks could withstand the impact of roof debris without failure. A subsequent analysis, 0200W-CA-C0033, *REDOX (202-S) Combined Seismic and Load Drop Effects on Cell Covers*, showed that the cover blocks would withstand the impact of roof debris even under seismic loading conditions. An additional analysis, 0200W-CA-C0156, *Evaluation of REDOX North Gallery Structure for Protection of Pu Loadout Hood*, showed that the north gallery structure would survive a seismic event with peak ground accelerations of 0.188 g (horizontal) and 0.122 g (vertical).

Based on engineering judgment, historical radiation surveys, and discussions with the REDOX Facility operating personnel, the vast majority of the MAR is thought to be inside process equipment and piping located within the process cells. To impact the material within a tank, the roof must collapse and cause the coverblocks to fail, which would subsequently cause the equipment to fail and result in a release from the tanks. A release would likely be much smaller than the postulated scenario due to the dissipation of kinetic energy associated with this chain of events.

Similarly, the material on the cell floor, which is conservatively assumed to be a powder, cannot be released in a roof failure without being impacted by significant force.

For this accident, the exhaust system is assumed to fail due to the event.

3.4.1.1.2 Scenario Development for 291-S Sand Filter

The most significant inventory outside the 202-S Canyon Building is the radiological hold-up in the 291-S Sand Filter. The structure is made of reinforced concrete; the top of the structure is exposed to the environment. In this accident, the seismic event causes a stack drop, which in turn impacts the Sand Filter.

Using the coordinates provided for the northeast corner of the sand filter (drawing H-2-5514) and the center of the stack (drawing H-2-5517), the distance between the two is calculated at 186.1 ft using the Pythagorean Theorem. This proves that the top 13.9 ft of the stack could directly strike the 291-S Sand Filter.

The following assumptions are used for the scenario development:

- The stack is conservatively assumed to fall in the worst possible manner, in a southwest direction, causing the top 13.9 ft of the stack to strike the Sand Filter roof. This value is rounded up to 15 ft for conservatism.
- The impact from the stack, combined with the earthquake, causes the entire roof to fail.
- The sand filter is below grade, constructed with pre-cast concrete beams and consists of a bed of gravel and sand constructed in layers. The roof is expected to collapse down into the structure. The roof and stack debris then impact the top layer of the sand filter material, which is 6.5 ft thick.
- For conservatism, the MAR is assumed to be homogenously distributed throughout the sand filter material. In reality, a higher concentration of MAR is expected to be

near the interface of the "E" and "F" layers of the filter (HW-56210), which is about 3 ft down (drawing H-2-8454).

3.4.1.2 Source Term Analysis

There are two contributors to the source term. First, the inventory contained within the 202-S Canyon Facility. Secondly, the inventory contained within the 291-S Sand Filter. These events are treated separately and their individual consequences are combined to represent the seismic accident.

3.4.1.2.1 Source Term from 202-S Building

The following parameters and assumptions are used for the 202-S portion of the source term analysis. This includes the canyon building; railroad tunnel, silo tower, process cells, process piping, process equipment building inventory, plus the North Sample Gallery for a total of 1,640 Ci of ^{239}Pu and 9,840 Ci of ^{90}Sr (see Table 3-2). Based on engineering judgment, historical radiation surveys, and discussions with the REDOX Facility operating personnel, the vast majority of the source term is thought to be inside process equipment and piping located within the process cells.

- A Damage Ratio (DR) of 1.0 is used
- A Leak Path Factor (LPF) of 1.0 is used
- Airborne release fraction (ARF) and release fraction (RF) values of 1.0E-03 and 1.0E-01, respectively, were chosen consistent with DOE-HDBK-3010-94, Section 4.4.3.3.2 and PRC-STD-NS-8739, Table D-1. Section 4.4.3.3.2 of DOE-HDBK-3010-94 describes the determination of the ARF and RF for the case where rocks are dropped onto open quart cans. The case of contamination in the canyon structure, process cells, process piping, process equipment, silo towers and process equipment in the North Sample Gallery is similar to the case of contamination in a can. The piping is like a small can, the equipment is like a moderate-sized can, the process cells are like a large can, and the canyon, silo, railroad tunnel and sample gallery are like very large cans. DOE-HDBK-3010-94 states that the ARF and RF for the case where the material is surrounded by the can is less than that for the case of material in a pile in the open, due to interaction of the particles of powder with each other, shielding of the powder by other portions of the powder, and interaction with the surfaces of the can. The cases of contamination within process equipment and piping is just like the experiment within DOE-HDBK-3010-94.

  Use of the lower ARF and RF for the case of contamination or powder in rooms or galleries is justified due to the interaction of the powder and contamination with the resulting debris (same as interaction with confining surface stated in DOE-HDBK-3010-94). The ARF and RF from DOE-HDBK-3010-94, Section 5.3.3.2.2 was not used because the condition is much different. In Section 5.3.3.2.2 the powder is released from the surface directly into the atmosphere. In the case of this accident, the powder is released into the room where it interacts with the falling debris (surfaces of previously standing walls and ceilings) and is removed from further transport.

- A χ/Q value at 100 m of 3.50E-03 s/m^3 (from DOE-STD-3009-2014) is used, which accounts for building wake effects.

The MAR in the 202-S Building for the Seismic Event is the total of the 202-S Canyon process area, Silo, process cells, piping, equipment, ancillaries, and North Sample Gallery MAR provided in Table 3-2. This is shown below in Table 3-6.

Table 3-6. Material at Risk in the 202-S Building

Isotope	202-S Inventory (g)	202-S Inventory (Ci)	Curie Fraction
^{90}Sr	7.21E+01	9.84E+03	8.57E-01
^{239}Pu	2.64E+04	1.64E+03	1.43E-01
Total	**2.65E+04**	**1.15E+04**	**1.00E+00**

3.4.1.2.2 Source Term from 291-S Sand Filter

The following parameters and assumptions are used for the 291-S portion of the source term analysis:

- The sand filter media was assumed to have properties comparable to contaminated soil with the MAR distributed homogenously throughout.
- A DR of 1.0 is used.
- An LPF of 1.0 is used.
- ARF and RF values of 1.2E-05 and 2.5E-01, respectively, were chosen consistent with PRC-STD-NS-8739, Table D-1. These values were derived from methods provided in DOE-HDBK-3010-94, Section 5.3.2.1.2. Appendix E provides calculations performed to verify these values are both bounding and conservative.
- The release is assumed conservatively to be a point source ground-level release and assumes no wake effect from the Canyon building.
- A χ/Q value of 3.28E-02 s/m^3 at 100 m is used as this event does not occur within a physical structure. This value is generated by RADIDOSE, which uses the methodology described in HNF-13007, *The 95th Percentile X/Q Values for RADIDOSE Version 3.0*.

The MAR in the 291-S Seismic Event is summarized in Table 3-7.

Table 3-7. Material at Risk in the 291-S Sand Filter

Isotope	291-S sand filter (g)	291-S sand filter (Ci)	Curie Fraction
^{90}Sr	5.86E+01	8.00E+03	9.59E-01
^{239}Pu	5.48E+03	3.40E+02	4.08E-02
Total	**5.54E+03**	**8.34E+03**	**1.00E+00**

3.4.1.3 Consequence Analysis

The risk of an unlikely and unmitigated Seismic Event is summarized in Table 3-8. The 202-S dose has been added to the 291-S dose for a TED. The RADIDOSE output for the sand filter component is identical to the analysis for the Sand Filter Load Drop accident (Section 3.4.5) therefore a note was made in the Sand Filter Load Drop output, and an additional calculation was not generated.

Table 3-8. Seismic Event Unmitigated Risk Summary

Receptor (Location)	202-S (rem)	291-S (rem)	TED (rem)	Risk Bin Values
Collocated Worker	2.30E+01	1.36E+00	2.44E+01	III
Maximally-Exposed Offsite Individual	1.89E-01	1.18E-03	1.90E-01	III

3.4.1.4 Comparison to the Evaluation Guidelines

The TED for the CW is below the risk guideline of 25 rem, which corresponds to a low consequence bin. A medium consequence bin was considered as 24.4 rem is close to the limit. The low consequence was kept however due to numerous conservatisms built into the analysis, e.g., damage ratios of 1, complete failure of the Sand Filter, conservative ARF and RF values for the Sand Filter (Appendix E), the 202-S MAR is treated as powder, as well as complete failure of the roof, coverblocks, and process equipment. Therefore, in reality, the dose would be much lower than 24.4 rem, and SS controls are not required.

Similarly, the TED to the MOI is below the 1 rem risk guideline, which corresponds to a low consequence bin.

3.4.1.5 Summary of Safety SSCs and TSR Controls

The unmitigated risk bin values for the CW and MOI are both III; no SC or SS SSCs or Technical Safety Requirements (TSRs) are required to prevent or mitigate the event.

Applicable SMPs that reduce the risk of this event include the Radioactive and Hazardous Waste Management Program and the Emergency Preparedness Program. The Radioactive and Hazardous Waste Management Program ensures that waste inventories are maintained and configuration, location, and quantities of hazardous waste are controlled. The Emergency Preparedness Program provides for assessing facility damage and potential releases of hazardous/radioactive materials if building integrity is potentially impacted. The Emergency Preparedness Program also provides for appropriate notification of all personnel who may potentially be impacted, including other contractor personnel.

3.4.2 PR Cage Fire

This operational event is a fire involving the deactivated process equipment located in the PR cage, which is enclosed by polymethyl methacrylate (PMMA) viewing panels. The analysis examines the risk associated with the PR cage that is identified in the preliminary hazards analysis and evaluated in the FHA.

3.4.2.1 Scenario Development

BHI-00994 determined that greater than 99 percent of the residual inventory is confined in lines and vessels. The FHA (CP-45673) states that peak temperatures (725 °F) are not expected to cause structural failure of the sample gallery (e.g., concrete walls, floor, and ceiling), the stainless-steel ion exchange vessels and piping in the PR cage or the stainless-steel ductwork. Consequently, the MAR is assumed to be the surface contamination that remains on the surfaces of the equipment and the PMMA viewing panels interior to the PR cage.

It was assumed in the original analysis, BHI-01142, that the contamination is equally split between the external equipment surfaces and interior surfaces of the PMMA panels of the PR Cage. BHI-01142 defines the residual contamination in the sump as 5.9 grams of ^{239}Pu and 2.5 Ci of ^{90}Sr (0.0182 g). BHI-01142 indicated that only limited samples for the interior surfaces of the PR Cage were available for the original analysis. Those samples indicated that the surface inventories may be less than the assigned inventory of the sump. Too few surface samples, however, were taken to assign inventory to the PR Cage interior surfaces. Use of the inventory of the sump was, therefore, judged to be conservative for the analysis. For this accident analysis, it was assumed that half of the total inventory is located on equipment surfaces and half is located on the PMMA panels. This model provides conservatism because higher release characteristics are used for the PMMA panels and because vertical surfaces are likely to retain less surface contamination than horizontal surfaces.

The following assumptions are used for the scenario development:

- Work activities in the area ignite the PMMA panels that surround the PR cage.
- The fire is allowed to burn unmitigated with no fire response provided.
- The inventory at risk is surface contamination that remains on the exposed surfaces of the equipment and the PMMA viewing panels in the PR cage.
- The exhaust ventilation is assumed to be out of service

3.4.2.2 Source Term Analysis

The following parameters and assumptions are used for the source term analysis:

- A DR of 1.0 is used
- An LPF of 1.0 is used
- ARF and RF values of 6.0E-03 and 1.0E-02, respectively, are used for the surfaces of the equipment that are internal to the PR cage. These values are found in PRC-STD-NS-8739, Table D-1. They are consistent with DOE-HDBK-3010, Section 4.4.1.1
- ARF and RF values of 5.0E-02 and 1.0E+00, respectively, are used for the interior surfaces of the PMMA viewing panels. These values are found in DOE-HDBK-3010, Section 5.2.1.4.2, which covers thermal stress on PMMA
- A χ/Q value at 100 m of 3.50E-03 s/m3 (from DOE-STD-3009-2014) is used, which accounts for building wake effects.

The MAR in the PR Cage Fire is summarized in Table 3-9.

Table 3-9. Material at Risk from PR Cage Fire

Isotope	PR Cage Inventory (g)	PR Cage Inventory (Ci)	PMMA Inventory (Ci)	Equip Surface Inventory (Ci)	Curie Fraction
^{90}Sr	1.83E-02	2.50E+00	1.25E+00	1.25E+00	8.72E-01
^{239}Pu	5.90E+00	3.66E-01	1.83E-01	1.83E-01	1.28E-01
Total	**5.92E+00**	**2.87E+00**	**1.43E+00**	**1.43E+00**	**1.00E+00**

3.4.2.3 Consequence Analysis

The risk of an anticipated and unmitigated fire event in the PR cage is summarized in Table 3-10. The PMMA dose has been added to the noncombustible equipment dose for a TED.

Table 3-10. Risk of a PR Cage Fire

Receptor (Location)	PMMA (rem)	Equip Surface (rem)	TED (rem)	Risk Bin Values
Collocated Worker	1.28E+00	1.53E-03	1.28E+00	III
Maximally-Exposed Offsite Individual	1.05E-02	1.26E-05	1.05E-02	III

3.4.2.4 Comparison to the Evaluation Guidelines

The TED for the CW is below the risk guideline of 25 rem, which corresponds to a low consequence bin. Similarly, the TED to the MOI is below the 1 rem risk guideline, which corresponds to a low consequence bin.

3.4.2.5 Summary of Safety SSCs and TSR Controls

The unmitigated risk bin values for the CW and MOI are both III. Therefore, it may be concluded that no SC or SS SSCs and no TSRs are required to prevent or mitigate the event.

Applicable SMPs that reduce the risk of this event include the Hazardous Material Protection Program which provides for hazard identification and controls (i.e., a job hazards analysis), Emergency Preparedness Program, and the Operational Safety Program which includes the Fire Protection Program.

The building structure does serve, to some extent, as a passive confinement barrier. As a result, the building structure is identified as defense-in-depth equipment. The USQ program is a key element of the SMPs which ensures configuration control of the confinement features.

3.4.3 Silo Fire

This operational event is a fire in the AMU areas of the Silo, which then propagates into the tower shaft housing the deactivated solvent extraction columns. An in depth analysis is provided in correspondence FH-0400890.

3.4.3.1 Scenario Development

The first five levels of the REDOX Silo consist of a tower shaft (remote process cell) and the adjacent operational areas consisting of the five aqueous makeup unit (AMU) levels. There are 17 oil-filled viewing windows in the wall between the AMU levels and the tower shaft. The windows have a total capacity of approximately 11,870 L (3,137 gal). An inspection on December 10, 2003, confirmed that oil remains in the majority of the viewing windows.

Applicable fire hazards include combustibles of the window oil and transient combustibles, ignition sources of the installed lighting system and transient ignition sources that may be required to perform characterization or risk reduction activities. Events that could lead to leakage include natural phenomena events such as earthquake, operational errors and degradation of the viewing window frames and seals. FH-0400890 provides an assessment of the likelihood of leaks of mineral oil from the viewing windows, and an assessment of the potential ignition source that applies to the REDOX Silo.

Common electrical services have the potential to provide ignition of flammable and some combustible materials. However, it is unlikely that the remaining electrical services have the potential to ignite a pool of mineral oil, should a major leak occur. The pool temperature for a sustained fire requires attainment of 182.2°C (360°F). The facility design is absent fixed combustibles or other energy sources to attain high temperatures in the mineral oil. However, potential characterization or risk reduction activities provide the potential for the introduction of transient combustibles that could burn and/or wick oil and thus support combustion. For purposes of an unmitigated analysis, it is assumed that a lack of institutional control leads to the accumulation of transient combustibles sufficient to combust leaked mineral oil.

A summary of the assumption bases for a fire in the REDOX Silo is defined below.

- Uncontrolled transient combustibles are allowed to accumulate in the AMU levels.
- An event occurs during characterization or risk reduction activities that causes the breakage of a viewing window and ignition of the mineral oil and transient combustibles adjacent to the viewing window.
- The majority of the mineral oil spills into the tower shaft.
- There is sufficient air in the tower shaft or from air inleakage to support full combustion.
- The fire burns without abatement and propagates into the tower shaft.
- The exhaust system is assumed to be out of service and the release occurs from leak points about the Silo and the connected laydown trench.

3.4.3.2 Source Term Analysis

All alpha emitting inventory is assumed as ^{239}Pu, and all fission products are assumed as ^{90}Sr. The inventory in the 202-S Canyon Building (Silo, process cells [piping and equipment]) is defined as 24,100 g of ^{239}Pu and 66.2 g of ^{90}Sr (Table 3-2). Additional inventory is defined for the north sample gallery and the sand filter, but for purposes of this evaluation, these may be ignored. This analysis assumes that 10 percent of the Canyon inventory, 2,410 g of ^{239}Pu and 6.62 g of ^{90}Sr is the contamination remaining in the tower shaft. This is consistent with Table 3-1, which states 10 percent of the 202-S MAR is in the Silo and column laydown trench.

The capacity of a large volume window is approximately 900 L (238 gal). The largest inventory of a given level is 1,125 gal (4,260 L). It is, therefore, reasonable to assume that a fraction of the Silo inventory is involved in the fire. The large spatial volume of the tower shaft would preclude the involvement of all the surface contamination. The heat evolution from one window would not breach the remaining process components (e.g., vessels and piping). It is, therefore, assumed that only 30 percent of the Silo's inventory will be available for release.

The following parameters and assumptions are used for the source term analysis:

- The MAR is assumed to be non-combustible surface contamination that remains in the tower shaft.
- A DR of 1.0 is used.
- An LPF of 1.0 is used.
- ARF and RF values of 6.0E-03 and 1.0E-02, respectively, are used for the surfaces of the equipment that are internal to the Silo. These values are found in PRC-STD-NS-8739, Table D-1. They are consistent with DOE-HDBK-3010, Section 4.4.1.1.
- A χ/Q value at 100m of 3.50E-03 s/m^3 (from DOE-STD-3009-2014) is used, which accounts for building wake effects.

Table 3-11 summarizes the MAR.

Table 3-11. Material at Risk During a Silo Fire

Isotope	Silo Inventory (g)	Silo Inventory (Ci)	Material at Risk (Ci)	Curie Fraction
^{90}Sr	6.59E+00	9.00E+02	2.70E+02	8.57E-01
^{239}Pu	2.42E+03	1.50E+02	4.50E+01	1.43E-01
Total	**2.43E+03**	**1.05E+03**	**3.15E+02**	**1.00E+00**

3.4.3.3 Consequence Analysis

The risk of an unlikely and unmitigated fire event in the REDOX Silo is summarized in Table 3-12.

Table 3-12. Unmitigated Risk for a Silo Fire

Receptor (Location)	TED (rem)	Risk Bin Values
Collocated Worker	3.77E-01	III
Maximally-Exposed Offsite Individual	3.10E-03	III

3.4.3.4 Comparison to the Evaluation Guidelines

The TED for the CW is below the risk guideline of 25 rem, which corresponds to a low consequence bin. Similarly, the TED to the MOI is below the 1 rem risk guideline, which corresponds to a low consequence bin.

3.4.3.5 Summary of Safety SSC and TSR Controls

The unmitigated risk bin values for the CW and MOI are both III. Therefore, it may be concluded that no SC or SS SSCs and no TSRs are required to prevent or mitigate the event.

Applicable SMPs that reduce the risk of this event include the Hazardous Material Protection Program which provides for hazard identification and controls (i.e., a job hazards analysis), the Operational Safety Program which includes the Fire Protection Program, and the Emergency Preparedness Program. The Emergency Preparedness Program provides for assessing facility damage and potential releases of hazardous/radioactive materials if building integrity is potentially impacted. The Emergency Preparedness Program also provides for appropriate notification of all personnel who may potentially be impacted, including other contractor personnel.

The building structure does serve, to some extent, as a confinement barrier. As a result, the building structure is identified as defense-in-depth equipment. The USQ program is a key element of the SMPs which ensures configuration control of the confinement features.

3.4.4 Canyon Load Drop

This operational event analyzes a crane failure or load drop impacting the 202-S Facility. Routine S&M activities in REDOX exclude use of the Canyon crane. However, during the facility's S&M history, the crane has been used to respond to upset conditions in the Canyon cells. Also, additional characterization of the Canyon facilities is expected to be required to support the decision documents required for final disposition. Therefore, crane operations are assumed to be contingent activities that may be required before final disposition of the facility.

3.4.4.1 Scenario Development

Crane operations are likely within the 202-S Building and over and around the 202-S Structure. Failure of the crane (with load) and nearby roof/wall structures is postulated in the crane drop event, as a heavy load such as cell cover blocks could be dropped accidentally causing a release into the Canyon air space. To bound this potential release, the following scenario is evaluated:

- A crane failure or load drop occurs over the 202-S roof.
- A localized roof failure occurs in close proximity (i.e., 150 ft) to the point of impact that generates missiles. ("Missiles" as used herein shall include any roof component or combination of components that could be postulated to fall from the roof and strike the deck or floors below).
- The drop occurs over an open or partially-opened cell (e.g., one or more cover blocks have been removed). Section 3.4.1 indicates that the coverblocks could withstand impact of roof debris without failure. However, considering the age of the facility and the fact that operations are limited to periodic S&M, it is conservatively assumed that a crane load drop event will result in a localized failure of the 202-S Building structure, including the coverblocks or two deck level floors (the equivalent thickness to a coverblock).
- The exhaust ventilation is assumed to be out of service.

3.4.4.2 Source Term Analysis

Limited data about the distribution of inventory in the REDOX Facility is available. Assuming that the residual contamination is relatively uniform in process components and cell surface areas, a reasonable but conservative source term can be derived.

Per Table 3-1, 90 percent of the inventory may be assumed to be distributed throughout the Canyon cells area. A cell cover block accidentally dropped from the maximum lift of the Canyon crane would have a significant potential to penetrate the cell and vessels. Assuming that a cell cover block is the load and a partially open cell is the target, the target area is relatively small compared to the deck surface area. The Canyon contains more than 60 vessels. If a dropped cover block impacts another cell cover, the load and the immediate target may collapse into the partially opened cell. That load drop could impact perhaps three of the major process vessels, or 5 percent of the Canyon process cells. For this analysis, it is conservatively assumed that 33 percent of the Canyon inventory is at risk from a load drop event in the 202-S Canyon Building.

The following parameters and assumptions are used for the source term analysis:

- The MAR is assumed to be 33 percent of the Canyon inventory. This MAR value bounds the inventory of any 202-S spaces located within 150 ft of each other. It is also noted that there are three deck levels (Crane Cab Deck, Pipe/Operating Gallery Deck, and Sample Gallery Deck) between these spaces and the roof. The cell coverblocks are the only separation between the cells and the roof.
- A DR of 1.0 is used.
- An LPF of 1.0 is used.
- ARF and RF values of 1.0E-03 and 1.0E-01, respectively, were chosen consistent with DOE-HDBK-3010-94, Section 4.4.3.3.2 and PRC-STD-NS-8739, Table D-1. The justification for use of these ARF and RF values is provided in Section 3.4.1.2.1
- A χ/Q value at 100 m of 3.50E-03 s/m^3 (from DOE-STD-3009-2014) is used, which accounts for building wake effects.

The MAR used to model the representative load drop event is summarized in Table 3-13.

Table 3-13. Material at Risk from Representative Load Drop

Isotope	Canyon Inventory (g)	Canyon Inventory (Ci)	Material at Risk 33% of Inventory (g)	Material at Risk 33% of Inventory (Ci)	Curie Fraction
^{90}Sr	6.59E+01	9.00E+03	2.20E+01	3.00E+03	8.57E-01
^{239}Pu	2.42E+04	1.50E+03	8.07E+03	5.00E+02	1.43E-01
Total	**2.43E+04**	**1.05E+04**	**8.09E+03**	**3.50E+03**	**1.00E+00**

3.4.4.3 Consequence Analysis

The risk of an anticipated load drop event in the 202-S Canyon Building is summarized in Table 3-14.

Table 3-14. Unmitigated Risk from Representative Load Drop

Receptor (Location)	TED (rem)	Risk Bin Values
Collocated Worker	6.99E+00	III
Maximally-Exposed Offsite Individual	5.74E-02	III

3.4.4.4 Comparison to the Evaluation Guidelines

The TED for the CW is below the risk guideline of 25 rem, which corresponds to a low consequence bin. Similarly, the TED to the MOI is below the 1 rem risk guideline, which corresponds to a low consequence bin.

3.4.4.5 Summary of Safety SSCs and TSR Controls

The unmitigated risk bin values for the CW and MOI are both III. Therefore, it may be concluded that no SC or SS SSCs or TSRs are required to prevent or mitigate the event.

Applicable SMPs that reduce the risk of this event include the Hazardous Material Protection Program (which includes evaluation of work place and job hazards), Emergency Preparedness Program, and the Operational Safety SMP which provides assurance of safe hoisting and rigging activities by implementing the requirements of DOE/RL 92 36, *Hanford Site Hoisting and Rigging Manual.* Implementation of DOE/RL-92-36 will serve to reduce the potential for a crane drop event, particularly one that could result in the catastrophic failure of the entire structure. The Emergency Preparedness Program provides for assessing facility damage and potential releases of hazardous/radioactive materials if building integrity is potentially impacted. The Emergency Preparedness Program also provides for appropriate notification of all personnel who may potentially be impacted, including other contractor personnel

The building structure does serve, to some extent, as a confinement barrier. As a result, the building structure is identified as defense-in-depth equipment. The USQ program is a key element of the SMPs which ensure configuration control of the confinement features.

3.4.5 Sand Filter Load Drop

This operational event analyzes a load drop on the 291-S Sand Filter, with subsequent roof collapse, as it contains the most significant inventory outside the 202-S Canyon Building.

3.4.5.1 Scenario Development

Equipment (e.g., cranes, forklifts) operations present a potential threat to confinement structures. Equipment accidents can damage them and have the potential to cause a release of radiological contamination to the environment and to expose workers. A representative accident is analyzed to confirm the risks of construction-related accidents.

The following assumptions are used for the scenario development:

- During maintenance activities, a crane is used to transport material to the Canyon or stack; control of the lift is lost, and a significant load is dropped onto the sand filter.
- The sand filter is below grade, constructed with pre-cast concrete beams and consists of a bed of gravel and sand constructed in layers. Considering its location, construction, makeup, and size (85 ft by 85 ft), the impact from a crane drop would be expected to be partially absorbed by the roof structure and result in limited damage to the confinement capability of the sand filter. For conservatism, the entire roof is assumed to fail and drop into the filter.
- Upon collapsing into the filter, the roof material impacts the top layer of the sand filter material, which is 6.5 ft thick. For conservatism and simplicity, the MAR is assumed to be homogenously distributed throughout the sand filter material. In reality a higher concentration of MAR is expected to be near the interface of the "E" and "F" layers of the filter (HW-56210), which is about 3 ft down (drawing H-2-8454).

3.4.5.2 Source Term Analysis

The following parameters and assumptions are used for the source term analysis:

- The sand filter media was assumed to have properties comparable to contaminated soil with the MAR distributed homogenously throughout.
- A DR of 1.0 is used.
- An LPF of 1.0 is used.
- ARF and RF values of 1.2E-05 and 2.5E-01, respectively, were chosen consistent with PRC-STD-NS-8739, Table D-1. These values were derived from methods provided in DOE-HDBK-3010-94, Section 5.3.2.1.2. Appendix E provides calculations performed using the DOE-HDBK-3010-94 methodology to verify these values are both bounding and conservative.
- The release is conservatively assumed to be a point source ground-level release and assumes no wake effect from the Canyon building.
- A χ/Q value at 100 m of 3.28E-02 s/m^3 is used as this scenario does not occur within a physical structure. This is value is generated by RADIDOSE, which uses the methodology described in HNF-13007, *The 95th Percentile X/Q Values for RADIDOSE Version 3.0*.

The MAR in the Sand Filter Load Drop event is summarized in Table 3-15.

Table 3-15. Material at Risk from a Load Dropped on the Sand Filter

Isotope	291-S sand filter (g)	291-S sand filter (Ci)	Curie Fraction
^{90}Sr	5.86E+01	8.00E+03	9.59E-01
^{239}Pu	5.48E+03	3.40E+02	4.08E-02
Total	**5.54E+03**	**8.34E+03**	**1.00E+00**

3.4.5.3 Consequence Analysis

The risk of an anticipated and unmitigated Sand Filter Load Drop is summarized in Table 3-16.

Table 3-16. Unmitigated Risk from a Load Dropped on the Sand Filter

Receptor (Location)	TED (rem)	Risk Bin
Collocated Worker	1.36E+00	III
Maximally-Exposed Offsite Individual	1.18E-03	III

3.4.5.4 Comparison to the Evaluation Guidelines

The TED for the CW is below the risk guideline of 25 rem, which corresponds to a low consequence bin. Similarly, the TED to the MOI is also below the 1 rem risk guideline, which corresponds to a low consequence bin.

3.4.5.5 Summary of Safety SSCs and TSR Controls

The unmitigated risk bin values for the CW and MOI are both III. Therefore, it may be concluded that no SC or SS SSCs and no TSRs are required to prevent or mitigate the event.

Applicable SMPs that reduce the risk of this event include the Hazardous Material Protection Program (which includes evaluation of work place and job hazards), Emergency Preparedness Program, and the Operational Safety SMP which provides assurance of safe hoisting and rigging activities by implementing the requirements of DOE/RL-92-36, *Hanford Site Hoisting and Rigging Manual*. The Emergency Preparedness Program provides for assessing facility damage and potential releases of hazardous/radioactive materials if building integrity is potentially impacted. The Emergency Preparedness Program also provides for appropriate notification of all personnel who may potentially be impacted, including other contractor personnel.

This DSA recognizes the confinement structure of the sand filter as defense-in-depth equipment. The USQ program is a key element of the SMPs which ensures configuration control of the confinement features.

3.4.6 Waste Staging Fire

This operational event involves an outside fire affecting staged waste. S&M activities generate contaminated waste. Typically, the waste packages are limited to incidental LLW or MLLW associated with contamination control of S&M activities. However, conditions may require risk-reduction activities that could lead to TRU waste from deactivated process components. This waste could generate TRU/transuranic mixed (TRUM) waste packages staged for transport and disposal.

The REDOX FHA evaluates a fire event for staged waste and the hazards analysis (Appendix A) assumes an event as anticipated.

3.4.6.1 Scenario Development

This analysis evaluates a representative fire event for waste staging in the REDOX yard. The following assumptions are used for the scenario development:

- Combustion-powered equipment is assumed for placing waste containers at a waste staging area outside the Canyon building.
- A liquid fuel or pool fire is assumed to occur that involves an assumed inventory of staged waste.
- TRU and TRU mixed waste will be staged in steel waste containers (e.g., steel waste disposal boxes, standard waste boxes, and/or waste drums) as provided by waste handling and disposal requirements. It is noted, the waste was conservatively assumed to be in wood boxes in the FHA, which were ignited by a vehicle collision. Although the equivalent megawatt fire size is conservative compared with the vehicle fuel pool fire, the accident dose consequence was analyzed as a point source ground level release and buoyant plume effects related to fire size were conservatively ignored.

3.4.6.2 Source Term Analysis

The inventory is estimated to represent the maximum TRU inventory that will be located in the staging area. The analysis assumes that the packaged waste contains an inventory equivalent to 100 grams of ^{239}Pu and a proportional amount of ^{90}Sr, such that the ^{90}Sr curies composes 0.857 of the total curies, and ^{239}Pu curies are 0.143 of the total curies (shown on Table 3-17). This assumption is protected by Specific Administrative Control (SAC) C.5.2, Waste Inventory Control.

A typical waste drum at REDOX is expected to consist primarily of step-off and contamination control waste and historically would be below 1 gram of ^{239}Pu. Use of 100 grams of ^{239}Pu and a proportional amount of ^{90}Sr anticipates that the waste will include a contaminated component or piece of equipment as well.

The following parameters and assumptions are used for the source term analysis:

- The inventory is assumed to be packaged waste that would be associated with step-off and contamination control waste.
- A DR of 1.0 is used
- An LPF of 1.0 is used
- ARF and RF values of 5.0E-04/1.0E+00, respectively, were chosen consistent with DOE-HDBK-3010-94, Section 5.2.1.1 and PRC-STD-NS-8739, Table D-1.
- The release is conservatively assumed to be a ground-level release and assumes no wake effect from the Canyon building.
- A χ/Q value at 100 m of 3.28E-02 s/m^3 is used as this scenario does not occur within a physical structure. This value is generated by RADIDOSE, which uses the methodology described in HNF-13007, *The 95th Percentile X/Q Values for RADIDOSE Version 3.0*.

The MAR in the Waste Staging fire is summarized in Table 3-17. The total Ci value is used in the dose consequence calculation (Appendix D, "Staged Waste Fire") and the total DE-Ci value is used in SAC C.5.2 *Waste Inventory Control.*

Table 3-17. Packaged Waste Material at Risk in a Waste Staging Fire

Isotope	Packaged Waste (g)	Packaged Waste (Ci)	Curie Fraction	DE-Ci
^{90}Sr	2.73E-01	3.72E+01	8.57E-01	1.79E-02
^{239}Pu	1.00E+02	6.21E+00	1.43E-01	6.21E+00
Totals	**1.00E+02**	**4.34E+01**	**1.00E+00**	**6.23E+00**

3.4.6.3 Consequence Analysis

The risk of an anticipated and unmitigated Waste Staging Fire is summarized in Table 3-18.

Table 3-18. Unmitigated Risk from a Waste Staging Fire

Receptor (Location)	TED (rem)	Risk Bin
Collocated Worker	4.06E+00	III
Maximally-Exposed Offsite Individual	3.56E-03	III

3.4.6.4 Comparison to the Evaluation Guidelines

The TED for the CW is below the risk guideline of 25 rem, which corresponds to a low consequence bin. Similarly, the TED to the MOI is below the 1 rem risk guideline, which corresponds to a low consequence bin.

3.4.6.5 Summary of Safety SSCs and TSR Controls

The unmitigated risk bin values for the CW and MOI are both III. Therefore, it may be concluded that no SC or SS SSCs are required to prevent or mitigate this event. However, because the inventory value is an assumed number and because of uncertainties regarding the actual staged TRU, an administrative SAC for inventory control (C.5.2) is a prudent control selection for the designated waste staging area.

Applicable SMPs that reduce the risk of this event include the Hazardous Material Protection Program which provides for hazard identification and controls (i.e., a job hazards analysis), Radioactive and Hazardous Waste Management Program which ensures waste inventories are maintained and configuration, location, and quantities of hazardous waste are controlled, Operational Safety Program which includes the Fire Protection Program, and the Emergency Preparedness Program. The Emergency Preparedness Program provides for assessing facility damage and potential releases of hazardous/radioactive materials if building integrity is potentially impacted. The Emergency Preparedness Program also provides for appropriate notification of all personnel who may potentially be impacted, including other contractor personnel

3.4.7 Internal Equipment Deflagration

This operational event involves a deflagration resulting from intrusive activities conducted on piping or equipment.

3.4.7.1 Scenario Development

Per Section 2.2.11, equipment may be removed from the REDOX Facility to reduce the risks from known hazards. This scenario analyzes the risk from a deflagration in a pipe or ductwork, resulting from the ignition of flammable vapors that may have accumulated in the equipment. The most common methods for cutting up process equipment and decontamination are mechanical means (e.g., saws, nibblers, cutters) that generate heat or torches that employ a flammable cutting gas. See CP-58929, *REDOX H-4 Line Remediation Hazards Analysis* for further details.

The following assumptions were used for the scenario development:

- Some of the process equipment contained flammable liquids, or solutions that could potentially create hydrogen gas via radiolysis reactions
- During remediation activities a tool generates heat, which ignites the flammable gas inside the equipment causing a deflagration.
- The deflagration may cause loose objects in the vicinity to become projectiles (missiles).
- The deflagration is confined to the equipment and does not affect adjacent structures or inventories.
- A bounding inventory of 60g Pu is used as it is the maximum amount of MAR, including measurement uncertainty of 1σ, expected to be in the entire H-4 line analyzed in CP-58929. The hazards analysis shows 47.7g Pu in the North Sample Gallery H-4 line, 60g is understood to be extremely conservative. An accident would be expected to involve 1g-10g at most. Using 60g is bounding for the analyzed hazard, and potential future activities.
- ^{90}Sr is not included in this analysis due to the dose factor of ^{90}Sr being orders of magnitude lower. Furthermore, no ^{90}Sr data was provided, the NDA data only provided grams of plutonium. Using the PFP Weapons Grade (WG) Pu mixture also yielded a more conservative result as it contained ^{241}Am in addition to higher level Pu isotopes.
- The exhaust ventilation is assumed to be out of service

3.4.7.2 Source Term Analysis

BHI-00994 determined that greater than 99 percent of the residual inventory is confined in lines and vessels. Consequently, the MAR is assumed to be the surface contamination that remains on the surfaces of the equipment.

The following parameters and assumptions are used for the source term analysis:

- ^{90}Sr is not included in this analysis due to the dose factor of ^{90}Sr being orders of magnitude lower. Furthermore, no ^{90}Sr data was provided, the NDA data only provided grams of plutonium. Using the PFP WG Pu mixture (RADIDOSE Facility/Material input 1) also yielded a more conservative result as it contained ^{241}Am in addition to higher level Pu isotopes, and was a reasonable assumption based on the mission of the facility when it was operating. The istotopic distribution is provided in Table 3-19.

- The MAR consists of 60 grams of PFP WG Pu mixture
- A DR of 1.0 is used
- An LPF of 1.0 is used
- A χ/Q value at 100 m of 3.50E-03 s/m^3 (from DOE-STD-3009-2014) is used, which accounts for building wake effects.

SARAH does not provide ARF and RF values for releases resulting from flammable gas deflagrations. The ARF and RF values of 5.0E-03 and 4.0E-01 used to derive consequences were based on DOE-HDBK-3010-94 values for the venting of pressurized powders. The powders used in the tests that provide these ARF and RF values have a very high RF. The handbook states that these ARF and RF values can be used to determine the source term for the venting of powders or confinement failure at pressures to approximately 25 psig or for large volume deflagrations (less than 25 percent of confinement volume) where confinement, such as a glovebox, fails at or less than approximately 25 psig (DOE-HDBK-3010-94). Trace quantities of legacy hazardous chemicals are expected in out-of-service REDOX equipment.

The likelihood of a chemical reaction involving the entire MAR in the equipment is considered remote, with a more likely scenario being the chemical reaction disturbing a small localized area. The amount of material affected (i.e., the DR) by the chemical reaction, however, is difficult to quantify. The use of the 5.0E-03 and 4.0E-01 ARF and RF values is considered overly conservative as the plutonium was originally in liquid form. It is assumed to have been Pu nitrate, as Pu nitrate was typical for processing, and dried Pu nitrate tends to produce gummy residues or solid masses rather than the light fluffy powder typically used in tests that provide the ARF and RF values in DOE-HDBK-3010-94 (See Appendix E, Section E.2). To account for this, the ARF×RF is reduced by a factor of 10, for a value of 2.0E-04. This reduction in ARF×RF will be incorporated into a combined ARF×RF value for accidents involving pipes and ductwork when calculating source term quantities for consequence calculations. A detailed justification for the ARF×RF reduction is located in Appendix E.

The MAR in the Internal Equipment Deflagration event is summarized in Table 3-19.

Table 3-19. Material at Risk from Internal Equipment Deflagration

Isotope	Max Inventory (g)	Max Inventory (Ci)	Curie Fraction
^{238}Pu	5.99E-03	1.02E-01	5.69E-03
^{239}Pu	5.62E+01	3.48E+00	1.94E-01
^{240}Pu	3.62E+00	8.34E-01	4.66E-02
^{241}Pu	1.20E-01	1.32E+01	7.37E-01
^{242}Pu	1.80E-02	7.02E-05	3.92E-06
^{241}Am	9.00E-02	2.88E-01	1.61E-02
Total	**6.00E+01**	**1.79E+01**	**1.00E+00**

3.4.7.3 Consequence Analysis

The risk of an anticipated and unmitigated internal equipment deflagration event is summarized in Table 3-20.

Table 3-20. Unmitigated Risk from an Internal Equipment Deflagration

Receptor (Location)	TED (rem)	Risk Bin Values
Collocated Worker	1.36E-01	III
Maximally-Exposed Offsite Individual	1.12E-03	III

3.4.7.4 Comparison to the Evaluation Guidelines

The TED for the CW is below the risk guideline of 25 rem, which corresponds to a low consequence bin. Similarly, the TED to the MOI is below the 1 rem risk guideline, which corresponds to a low consequence bin.

3.4.7.5 Summary of Safety SSCs and TSR Controls

The unmitigated risk bin values for the CW and MOI are both III. Therefore, it may be concluded that no SC or SS SSCs and no TSRs are required to prevent or mitigate the event based on calculated dose values. SAC C.5.3 Flammable Atmosphere Control was created however as the major receptor at risk is the FW performing intrusive operations on abandoned process equipment; this receptor could potentially sustain serious injury in the event of an internal deflagration.

Applicable SMPs that reduce the risk of this event include the Hazardous Material Protection Program (which includes evaluation of work place and job hazards), the Operational Safety Program (Fire Protection Program), and the Emergency Preparedness Program. The Emergency Preparedness Program provides for assessing facility damage and potential releases of hazardous/radioactive materials if building integrity is potentially impacted. The Emergency Preparedness Program also provides for appropriate notification of all personnel who may potentially be impacted, including other contractor personnel.

The building structure does serve, to some extent, as a confinement barrier. As a result, the building structure is identified as defense-in-depth equipment. The USQ program is a key element of the SMPs which ensures configuration control of the confinement features.

3.4.8 Aircraft Impact Event

This man-made external event involves a localized failure of the 202-S Building due to an aircraft impact. In accordance with DOE-STD-3014-2006, *Accident Analysis for Aircraft Crash into Hazardous Facilities*, an evaluation was performed to assess the significance of the aircraft crash risk on the REDOX facility. The details of the aircraft crash frequency are documented in CP-56944, *CP S&M Aircraft Impact Frequency Analysis: PUREX*. The evaluation determined that the "impact frequency" per year for the 202-A Structure is 4.25E-06, which could also be used for 202-S per Attachment 2 of CP-56944. This impact frequency equates to a frequency category of "Extremely Unlikely" in Table 3-3. In accordance with STD-3014-2006, impact frequencies greater than "Beyond Extremely Unlikely" (10-6/yr.) require further evaluation.

3.4.8.1 Scenario Development

An aircraft (i.e., missile) impact into the REDOX facility structure can cause a local response or damage at the point of contact. In addition to a mechanical impact, it is anticipated that the fuel contained within the aircraft will spread out and burn. These events are treated separately and their individual consequences are added to represent the Aircraft Impact Event.

3.4.8.1.1 Scenario Development for Structural Penetration (Mechanical)

An aircraft (i.e., missile) impact into the REDOX Facility can cause a local response or damage at the point of contact. For concrete structures, this local response or damage is characterized as penetration and spalling, scabbing, punching shear, and perforation of building structural components (e.g., a wall or floor) that may not result in the overall failure or collapse of the whole building structure. The results of the structural response evaluation will be compared to the following DOE-STD-3014-2006 guidelines for various types of damage:

Local damage to reinforced concrete targets:

1. Scabbing: A local damage that signifies the peeling off (or ejection) of material from the back face of the target. To prevent scabbing, required wall thickness is 110 percent of the predicted scabbing thickness;
2. Perforation: A local damage that signifies that the missile fully penetrates the target or passes through the target. To prevent perforation, required wall thickness is 120 percent of the predicted perforation thickness.
3. Punching shear: Local shear failure occurring in the immediate vicinity of the impacted zone. Punching shear may occur as part of the perforation process. To prevent punching shear failure, the predicted punching shear stress should not exceed four times the square root of the compressive strength of concrete (f'c) at the perimeter one-half the effective depth away from the load.

The selection of representative aircraft in the general aviation category and the minimum thickness of reinforced concrete needed to prevent scabbing was based on SNF-19500, *Assessment of Aircraft Impact on the Canister Storage Building and Cold Vacuum Drying Facility*. SNF-19500 concluded that the aircraft with the highest impact hazard is a twin-engine, fixed-wing, general aviation aircraft (Raytheon King Air B200, formerly known as Beechcraft B200). This aircraft had the highest impact frequency, thus, poses a greater hazard than those aircraft with frequencies of 1.0E-08 or less. The B200 is an aircraft with a take-off weight of 12,500 lbs. (5,670 kg) and a fuel capacity of 544 gal (3,645 lb./1,654 kg). This aircraft is postulated to impact the top (roof) or side of the 202-S Building or Silo.

For the reinforced concrete targets the aircraft missile, like the engine, can cause spalling, scabbing or perforation. Typically spalling is not a safety concern and it is sufficient to evaluate safety related targets for scabbing and perforation, i.e., full penetration (DOE-STD-3014-2006). Scabbing is defined as local damage that causes peeling off (or ejection) of material from the back face of the target and spalling causes ejection of material from the front face of the target. The critical parameter in determining whether the target can withstand scabbing or perforation is the thickness. SNF-19500 determined that the minimum thickness of reinforced concrete needed to prevent scabbing from the (B200) aircraft missile (engine) in the vertical impact direction is 14.3 in. and 5.7 in. for the horizontal impact. This analysis conservatively uses a concrete thickness of 18 in. (vertical) and 12 in. (horizontal) to determine locations of the 202-S structure vulnerable to penetration.

In this accident scenario, the aircraft missile, such as the engine, impacts and breaches the 202-S Building. A localized roof failure occurs at the point of impact that generates missiles. ("Missiles" as used herein shall include the aircraft engine and any roof component or combination of components which could be postulated to fall from the roof and strike the deck or floors below). This is deemed a conservative assumption given the thickness of the facility walls and the fact that most of the MAR would be located in subsurface concrete spaces with thick ceiling/floors and cell block covers.

The canyon area proper is a long narrow concrete structure with 30 in. (min) thick walls and a concrete roof deck that has 9 in. and 5 in. thick sections. The canyon is subdivided into process cells paralleled on the north and south sides by 5 gallery levels (with concrete deck floors/ceilings). The process cells are typically covered with concrete cover blocks typically 24 in. to 48 in. thick. The Crane Gallery deck (top level) is 18 in. thick, and the Pipe/Operating Gallery and Sample Gallery floors are each 12 in. (minimum) thick.

- Penetration into the pipe and sample gallery spaces from the aircraft missile would have to result in the failure of the Canyon roof (both 5 in. and 9 in. thick sections), the crane gallery deck (18 in.), and the pipe/operating gallery floor (12 in.) on the south side, and pipe/operating gallery floor (12 in.) on the north side
- Penetration into the process cell spaces from the aircraft missile would have to result in the failure of the Canyon roof (both 5 in. and 9 in. thick sections), and at least one coverblock (30 in. minimum)

As there are portions of the 202-S Building structure that are below the minimum concrete thickness required to prevent scabbing or penetration from the postulated aircraft missile, like the engine, the event is assumed to cause a localized failure of the 202-S structure. The local structural failure due to an aircraft missile, such as the engine, is considered to be bounded by the local structural failure caused by a crane/load drop event (Section 3.4.4). Therefore the consequences of the mechanical impact of the aircraft missile that produces a structural failure (local penetration) of the confinement barrier, whose debris, in turn, impacts contaminated equipment and surfaces within the 202-S structure, subsequently causing an uncontrolled release of radiological material to the atmosphere is assumed to be similar to those evaluated in the failure of the 202-S Building due to a load drop event.

- The aircraft missile impacts the 202-S Structure (roof) causing a local structural failure.
- A localized roof failure occurs at the point of impact that generates missiles.
- It is assumed that such an accident at the 202-S Building results in a localized roof/wall structural failure. Section 3.4.1 indicates that the coverblocks could withstand impact of roof debris without failure. However, considering the age of the facility and the fact that REDOX operations are limited to periodic S&M, it is conservatively assumed that an aircraft impact event, like a crane load drop event, will result in a localized failure of the 202-S Building structure, including the coverblocks or two deck level floors (the equivalent thickness to a coverblock).

3.4.8.1.2 Scenario Development for Burning Fuel

It is assumed that the B200 fuel tank is full, with a fuel capacity of 544 gal (3645 lbs /1,654 kg), and that all of the fuel enters the 202-S structure and spreads out to cover a third of the Canyon. The area would likely be smaller due to fuel draining into enclosed areas such as Canyon cells. This candidate exposed area is assumed to contain the same MAR as discussed above in Section 3.4.8.1.1.

The scenario assumes that the resulting fire burns with sufficient energy to result in releasing material to the environment. The event is a short duration event, so an acute ground release without plume meander is used to model the potential consequences. No credit was taken for any fractional reduction in the MAR by the accident-generated conditions.

It is assumed that 10 percent of the inventory in the fire consists of dust debris, sludge, and some remaining plutonium and oxide and minor quantities of step-off pad or packaged waste. The remaining 90 percent consists of contaminated tanks and equipment.

3.4.8.2 Source Term Analysis

There are two contributors to the source term. First, the mechanical impact of the aircraft missile produces a structural failure (local penetration) of the confinement barrier whose debris impacts contaminated equipment and surfaces within the 202-S Structure and causes an uncontrolled release of radiological material to the atmosphere. Secondly, aircraft fuel spreads across contaminated surfaces and burns, causing radioactive aerosol to be released. These events are treated separately and their individual source terms are added to represent the Aircraft Impact Event.

3.4.8.2.1 Source Term from Structural Penetration (Mechanical)

The following parameters and assumptions are used for the Structural Penetration (Mechanical) portion of the source term analysis:

- The MAR is assumed to be 33 percent of the Canyon inventory. This MAR value bounds the inventory of any 202-S spaces located within 150 ft of each other. It is also noted that there are three deck levels (Crane Cab Deck, Pipe/Operating Gallery Deck, and Sample Gallery Deck) between these spaces and the roof. The cell coverblocks are the only separation between the cells and the roof.
- A DR of 1.0 is used.
- An LPF of 1.0 is used.
- ARF and RF values of 1.0E-03 and 1.0E-01, respectively, were chosen consistent with DOE-HDBK-3010-94, Section 4.4.3.3.2 and PRC-STD-NS-8739, Table D-1. The justification for use of these ARF and RF values is provided in Section 3.4.1.2.1.
- A χ/Q value at 100m of 3.50E-03 s/m^3 (from DOE-STD-3009-2014) is used, which accounts for building wake effects.

The MAR in the aircraft mechanical impact is summarized in Table 3-21.

Table 3-21. Material at Risk from Aircraft Mechanical Impact Component

Isotope	Canyon Inventory (g)	Canyon Inventory (Ci)	Material at Risk 33% of Inventory (g)	Material at Risk 33% of Inventory (Ci)	Curie Fraction
^{90}Sr	6.59E+01	9.00E+03	2.20E+01	3.00E+03	8.57E-01
^{239}Pu	2.42E+04	1.50E+03	8.07E+03	5.00E+02	1.43E-01
Total	**2.43E+04**	**1.05E+04**	**8.09E+03**	**3.50E+03**	**1.00E+00**

3.4.8.2.2 Source Term from Burning Fuel

The total MAR is assumed to be 3.5E+03 Ci. This is 33 percent of the inventory for the 202-S Canyon. 10 percent of this MAR is treated as combustible, with the remaining 90 percent treated as non-combustible, contaminated solids.

- For the 10 percent combustible component, ARF and RF values of 6.0E-03 and 1.0E-01, respectively, were used for fires involving Pu oxides and other powders. This value is based on bounding values for combustion of dust debris, sludge, and some remaining plutonium and oxide and minor quantities of step-off pad or packaged waste. These values are consistent with PRC-STD-NS-8739, Table D-1.
- For the 90 percent non-combustible component, ARF and RF values of 6.0E-03 and 1.0E-02, respectively, were used for non-combustible contaminated solids. Since the majority of the inventory within the facility is contaminated tanks and equipment, the use of these ARF and RF values is appropriate. These values are consistent with DOE-HDBK-3010-94, Sections 4.4.1.1 and 4.4.1.2 and PRC-STD-NS-8739, Table D-1.
- A DR of 1.0 is used.
- An LPF of 1.0 is used.
- A χ/Q value at 100m of 3.50E-03 s/m^3 (from DOE-STD-3009-2014) is used, which accounts for building wake effects

The MAR in the aircraft impact fire component is summarized in Table 3-22.

Table 3-22. Material at Risk from Aircraft Fire Component

Isotope	Material At Risk (g)	Material At Risk (Ci)	90% Noncombustible Component (Ci)	10% Combustible Component (Ci)	Curie Fraction
^{90}Sr	2.20E+01	3.00E+03	2.70E+03	3.00E+02	8.57E-01
^{239}Pu	8.07E+03	5.00E+02	4.50E+02	5.00E+01	1.43E-01
Total	**8.09E+03**	**3.50E+03**	**3.15E+03**	**3.50E+02**	**1.00E+00**

3.4.8.3 Consequence Analysis

The risk of an extremely unlikely and unmitigated aircraft crash event is summarized in Table 3-23. The mechanical impact dose has been added to the combustible and noncombustible equipment doses for a TED.

Table 3-23. Aircraft Crash Event Unmitigated Risk Summary

Receptor (Location)	Mechanical (rem)	Fire: 10% Combustible (rem)	Fire: 90% Noncombustible (rem)	TED (rem)	Risk Bin Values
Collocated Worker	6.99E+00	4.19E+00	3.77E+00	1.5E+01	IV
Maximally-Exposed Offsite Individual	5.74E-02	3.44E-02	3.10E-02	1.23E-01	IV

3.4.8.4 Comparison to the Evaluation Guidelines

The TED for the CW is below the risk guideline of 25 rem, which corresponds to a low consequence bin. Similarly, the TED to the MOI is below the 1 rem risk guideline, which corresponds to a low consequence bin.

3.4.8.5 Summary of Safety SSCs and TSR Controls

The unmitigated risk bin values for the CW and MOI are both IV. Therefore, it may be concluded that no SC or SS SSCs and no TSRs are required to prevent or mitigate the event.

Applicable SMPs that reduce the risk of this event include the Hazardous Material Protection Program (which includes evaluation of work place and job hazards), the Operational Safety Program (which includes the Fire Protection Program), and the Emergency Preparedness Program. The Emergency Preparedness Program provides for assessing facility damage and potential releases of hazardous/radioactive materials if building integrity is potentially impacted. The Emergency Preparedness Program also provides for appropriate notification of all personnel who may potentially be impacted, including other contractor personnel.

3.5 Safety Systems, Structures, and Components

From Section 3.4 and Appendix A of this DSA, there are two SSCs associated with the REDOX Facility that warrant further evaluation. The SSCs of interest are the building structure and the ventilation system. The evaluation of these SSCs is discussed in Section 4.1 of this DSA. The section concludes that there are no SS or SC SSCs.

3.6 Margins of Safety

There is no explicit margin of safety identified in this DSA. Margin of Safety must be an explicit function between a design or assumed failure point and its associated safety limit. This DSA does not contain safety limits and does not have SC SSCs that if they failed, would result in a potential release greater than 25 rem to the MOI. There are no implicit margins of safety for this facility. Therefore, since there are no explicit or implicit margins of safety associated with this facility, the margin of safety question in USQ evaluations performed against this DSA should be answered "No."

Chapter 4.0

Hazard Controls

Contents

Tables

4.0 Hazard Controls

This chapter identifies the facility features and control elements required for long-term S&M activities at the REDOX Facility. It provides details about facility equipment and features that are necessary to satisfy the current risk evaluation guidelines, provide defense in depth, and contribute to worker safety. The controls presented here are based on the results of the HA (Appendix A) and accident analyses for S&M activities at the REDOX Facility, as described in Chapter 3.0

4.1 Safety Structures, Systems, and Components

This section evaluates the REDOX SSCs for SC, SS, or defense-in-depth classification. Table 4-1 provides a summary of the accidents analyzed in Chapter 3.0 for reference.

Table 4-1. Accident Scenario Summary

Scenario (unmitigated)	Frequency	Onsite TED (rem)	Offsite TED (rem)	Risk Bin Values
Seismic event (Section 3.4.1)	Unlikely	2.44E+01	1.90E-01	III
PR cage fire (Section 3.4.2)	Anticipated	1.28E+00	1.05E-02	III
Silo fire (Section 3.4.3)	Unlikely	3.77E-01	3.10E-03	III
Canyon load drop (Section 3.4.4)	Anticipated	6.99E+00	5.74E-02	III
Sand filter load drop (Section 3.4.5)	Anticipated	1.36E+00	1.18E-03	III
Waste staging fire (Section 3.4.6)	Anticipated	4.06E+00	3.56E-03	III
Internal Equipment Deflagration (Section 3.4.7)	Anticipated	1.36E-01	1.12E-03	III
Aircraft Impact Event (Section 3.4.8)	Extremely Unlikely	1.5E+01	1.23E-01	IV

4.1.1 Safety Class SSCs

All of the accident analyses in Chapter 3.0 identified "low" consequences to the MOI, as such, no SC SSCs are required or identified at the REDOX Facility. The bases for this determination are the current criteria for selecting SC SSCs identified in PRC-PRO-NS-700 and SARAH (PRC-STD-NS-8739).

4.1.2 Safety Significant SSCs

All of the accident analyses in Chapter 3.0 identified "low" consequences to the CW; as such, no SS SSCs are required or identified at the REDOX Facility.

SS controls are also required to be considered for events that present high consequences to the facility worker, such as events that could cause prompt death, serious injury, or significant radiological or chemical exposure. The Internal Equipment Deflagration event (Section 3.4.7) was identified in the accident analyses as potentially having high consequences to the facility worker. Due to the nature of the accident, no SSCs were identified, therefore, SAC C.5.3 was developed.

4.1.3 Defense-In-Depth

SSCs are evaluated for defense-in-depth designation, if they are below the criteria for SC and SS.

The REDOX 202-S Building structures, which include the Canyon walls and roof, and the 291-S Sand Filter structure discussed in Table 4-2 are designated as providing defense in depth. The 202-S Building structures and the 291-S Sand Filter structure are not credited in the accident analyses for providing a preventive or mitigative function; however, the 202-S Building structures provide confinement of hazardous materials and shielding for worker protection during normal operations and accidents and the retired filter structure provides confinement of hazardous materials and protection of filter material from impact.

Changes to defense-in-depth equipment are considered significant modifications. The USQ process required by 10 CFR 830 ensures that changes are appropriately analyzed and controlled so they do not adversely affect safe operation.

Table 4-2. Defense-in-depth Equipment (general service)

Element	Boundary definitions and safety functions	Basis for DID and applicability
202-S Building structures (including Canyon, galleries, Silo, and cover blocks)	**Boundary**: The physical boundary includes the foundation, cover blocks, walls, and ceiling/roof of the structures. **Defense-in-depth safety function**: • **Confinement** – The robust facility structures provide degree of confinement of the MAR within the facility during normal operations and some accident conditions.	The structures perform an important defense-in-depth function (DOE G 424.1-1B). The structure safety function is effective for multiple hazards (PRC-PRO-NS-700).
291-S Sand Filter structure	**Boundary**: The sand filter physical boundary includes the below grade foundation and wall structures and the cover blocks. **Defense-in-depth safety function**: • **Confinement** - The sand filter structure provides degree of confinement of the MAR within the filter during normal operations and some accident conditions.	The sand filter structure performs an important defense-in-depth function (DOE G 424.1-1B). The structure safety function is effective for multiple hazards (PRC-PRO-NS-700).

DOE G 424.1-1B, *Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements*

Although the ventilation system is not considered to be a defense-in-depth system, it helps minimize the spread of airborne contamination within and from the REDOX Facility, providing an enhanced level of contamination control which is consistent with as low as reasonably achievable principles. The system will be operated and maintained such that its capabilities do not deteriorate, consistent with the existing design and applicable federal and WDOH requirements. The CP S&M Organization will monitor and maintain the REDOX exhaust ventilation system through surveillance programs, evaluations, and repairs as required to maintain confinement capability and minimize hazard migration from the REDOX Facility.

4.2 Design Features

There are no Design Features identified at the REDOX Facility.

4.3 Administrative Controls

To ensure that assumptions of this DSA are maintained and to ensure continued safe management of the facility, one Administrative Control (AC) and two Specific Administrative Controls (SACs) are provided.

4.3.1 Administrative Control (AC C.5.1)

AC C.5.1 is identified to ensure establishment, implementation, and assessment of applicable SMPs.

4.3.2 Specific Administrative Control (SAC C.5.2)

SAC C.5.2 is identified to limit the total externally-staged TRU waste and TRU contaminated equipment removed from REDOX buildings to less than 6.23 DE-Ci, which preserves the assumptions used in the analysis performed in Section 3.4.6. This control is identified as a SAC as it is **required** to protect key accident assumptions and consequences.

4.3.2.1 Safety Function – Waste Inventory Control

The Source Strength Control C.5.2 ensures that TRU waste inventories assumed in the REDOX DSA staged-waste fire accident analysis (Section 3.4.6) will not be exceeded. This control is designated as a SS TSR SAC because its function is credited to maintain the staged waste fire accident consequences within the bounds of the analysis, involves physical actions that involve the waste, and would be SS if performed by equipment.

4.3.2.2 Specific Administrative Control Description – Waste Inventory Control

The Waste Inventory Control (C.5.2) provides a DE-Ci limit for TRU waste staged externally at REDOX. Processes are established within the REDOX complex to track the inventory of staged TRU and TRU contaminated equipment removed from REDOX. A lower operational limit may be established to prevent violating the limit established in the TSR SAC. Operations personnel are trained to validate that the TSR SAC limit will not be violated prior to initiating waste movements.

No SS SSCs are required for compliance with this SAC.

4.3.2.3 Functional Requirements – Waste Inventory Control

The functional requirement to fulfill the safety function of this SAC is to verify that waste staged externally at REDOX is less than 6.23 DE-Ci. Verification may be based on nondestructive assay, radiological surveys, and/or historical documentation and process operations.

4.3.2.4 Specific Administrative Control Evaluation – Waste Inventory Control

Prohibiting the addition of radiological material to the REDOX Facility inventory protects the accident assumptions in Chapter 3.0. The USQ process and implementing procedures adequately protect this TSR element.

4.3.2.5 Technical Safety Requirement Control

The SAC is written in the format of a specific directed action to control MAR within the bounds of the accident analyses and provide unequivocal MAR limits.

4.3.3 Specific Administrative Control (SAC C.5.3)

SAC C.5.3 is identified to prevent a deflagration from occurring in legacy piping or equipment subjected to intrusive operations as part of remediation or pre D&D work. This control is designated as an SAC as it is required to prevent the FW from sustaining a serious injury from a deflagration, or by flying objects (missiles) created by the deflagration.

4.3.3.1 Safety Function—Flammable Atmosphere Control

The Flammable Atmosphere Control C.5.3 ensures that systems with a potentially flammable atmosphere will be evaluated, vented, and monitored. This control is designated as a SS TSR (SAC) because its function is credited to prevent the FW from sustaining serious injury caused by an internal deflagration, or from flying objects (missiles) created by the deflagration. This operational event is described in the accident analysis, Section 3.4.7.

4.3.3.2 Specific Administrative Control Description—Flammable Atmosphere Control

The Flammable Atmosphere Control (C.5.3) prevents deflagrations in piping and equipment by requiring systems with potentially flammable atmospheres be evaluated. If flammable gasses or vapors are determined to be potentially present in piping and equipment, those systems are required to be vented to less than 10 percent of the Lower Explosive Limit (LEL), ensuring the gas or vapor mixture is too lean to support combustion (LEL is assumed to be equal to LFL). This is followed by confirmative monitoring prior to use of mechanical cutting devices. If venting and monitoring cannot be performed, an approved process that imparts limited energy may be used.

No engineering controls were identified for this SAC due to the variable nature of remediation and D&D prep tasks. A task controlled by this SAC could potentially be in any number of areas and require a wide variety of tools and methods.

No SS SSCs are required for compliance with this SAC.

4.3.3.3 Functional Requirements—Flammable Atmosphere Control

Functional requirements of this SAC are provided by Industrial Hygiene. The infrastructure and methodology required to implement this control are expected to already be in place, as this hazard is also covered by the Hazardous Material Protection SMP. To implement this control, equipment for detecting, quantifying, and monitoring flammable gasses and vapors is required. Additionally equipment for purging systems with a flammable atmosphere are required, which will likely include bottle or line-supplied inert gas.

If it is not feasible to perform venting and monitoring, approved equipment that imparts minimal energy during the process will be required. More information, including an example, can be found in CHPRC-1502750, *The Crimp/Cut (or Shearing) Method of Size Reducing Pipe Constitutes a "Cold Cutting" Technique*.

4.3.3.4 Specific Administrative Control Evaluation—Flammable Atmosphere Control

To satisfy the Flammable Atmosphere Control, the detection and monitoring equipment must have current calibration showing that the device is within factory tolerances. If it is not feasible to perform venting and monitoring, the guidance provided in CHPRC-1502750 shall be used for choosing acceptable tools.

4.3.3.5 Technical Safety Requirement Control

This SAC is written in the format of a specific directed action to prevent deflagrations in piping and equipment by evaluating and controlling potentially flammable atmospheres, followed by confirming that the preventative activities were effective.

4.4 Hazard Control Derivation Basis

Building features and controls serve to reduce the potential risk to the public and FWs from uncontrolled releases of radiological materials. REDOX Facility structures are identified as defense-in-depth equipment within the accident analyses presented in Section 3.4. Key programmatic commitments in Chapter 3.0 and Chapter 4.0 are elements of the site SMPs as described in Chapter 5.0 and specified in AC C.5.1.

4.5 Step-Out Criteria

The REDOX Facility can be reclassified as below HC-3 when sufficient radioactive material is removed to lower the radioactive material inventory below the HC-3 threshold. Reclassification of the REDOX Facility as a below HC-3 Facility will require DOE approval and a formal Implementation Verification Review.

Those buildings identified as Less Than HC-3 facilities within this DSA may undergo demolition and final remediation activities using an approved Health and Safety Plan and applicable SMPs. Likewise, utilities that exist in the facility 'yard' area (outside the Haz Cat 2 & 3 structures but within the facility boundary) that are determined to be Less Than HC-3 may also undergo demolition and final remediation. Demolition and remediation activities are anticipated to include the use of equipment such as dump trucks, front-end loaders, graders, fork lifts, cranes, etc. The activities may require the use of scaffolding or other temporary structures to facilitate demolition. Demolition and final remediation impacts on adjacent nuclear facilities shall be evaluated using the USQ process and may be pursued provided the USQ evaluation yields a negative USQ.

For buildings and utilities that are not designated as Less Than HC-3 in the existing DSA, a Hazard Categorization demonstrating the building/utilities are Less Than HC-3 shall be prepared and submitted to RL as a separate document or summarized in the DSA for approval. Upon approval, the demolition and final remediation activities associated with the buildings and utilities adjacent to the nuclear facilities shall be evaluated using the USQ process and, provided the USQ review yields a negative USQ, they may undergo demolition and final remediation using an approved Health and Safety Plan and applicable SMPs. Demolition and remediation activities are anticipated to include the use of equipment such as dump trucks, front-end loaders, graders, fork lifts, cranes, etc. The activities may require the use of scaffolding or other temporary structures to facilitate demolition. The DSA, if not revised during the Hazard

Categorization process, will be revised to reflect this new hazard categorization and building status in the next annual update as appropriate.

Chapter 5.0

Safety Management Programs

Contents

5.0 Safety Management Programs

A summary of the key programmatic commitments is provided in this chapter. Additional detail regarding the requirements, drivers, and program descriptions may be found in HNF-11724, *CH2M HILL Plateau Remediation Company Safety Management Programs*.

Additionally, there are other site programs that are implemented by the performing organization to fulfill CHPRC's commitments to the Integrated Environmental, Safety, and Health Management System (ISMS). Details of the approved system, especially for the work control processes may be found in PRC-MP-MS-003, *Integrated Safety Management System/Environmental Management System Description.*

5.1 Prevention of Inadvertent Criticality

The Hanford Site Criticality Safety Program (HNF-7098) is implemented through facility programs and procedures. The REDOX Facility is classified as a limited-control facility because the contents may contain greater than half of a minimum critical mass, but a criticality is determined to be incredible in HNF-36331 where fissionable material is not disturbed. For activities affecting the form/distribution of the fissile material, a criticality is judged to be incredible per CHPRC-02595.

Note the limit imposed on activities involving fissile material by SAC C.5.2 Waste Inventory Control is 100 grams, more restrictive than the 150 gram limit imposed by CHPRC-02595. The SAC limit supersedes the CSER limit.

The Criticality Safety Program is described in Chapter 6.0 of HNF-11724. No exceptions are taken to the key attributes pertaining to a limited-control facility, as described in HNF-11724.

5.2 Radiation Protection

The Radiation Protection Program implements applicable regulatory (10 CFR 835 *Occupational Radiation Protection*) and other contractual requirements. The program is based on functional or operational organizations implementing the necessary requirements. The Radiological Control Program is described in Chapter 7.0 of HNF-11724. No exceptions are taken to the key attributes as described in HNF-11724.

5.3 Hazardous Material Protection

The Hazardous Material Control Program is found in Chapter 8.0 of HNF-11724. No exceptions are taken to the key attributes as described in HNF-11724.

5.4 Radioactive and Hazardous Waste Management

The Radioactive and Hazardous Waste Management Program is found in Chapter 9.0 of HNF-11724. No exceptions are taken to the key attributes as described in HNF-11724.

5.5 Initial Testing, In-Service Surveillance, and Maintenance

The REDOX Facility is currently in S&M mode with limited occupancy for S&M activities. The building is normally locked and access is controlled by approved procedures of the CP S&M Organization. The scope of activities to be performed is summarized in Section 2.2. The Initial Testing, In-service Surveillance, and Maintenance Program is found in Chapter 10.0 of HNF-11724. No exceptions are taken to the key attributes as described in HNF-11724.

5.6 Operational Safety

The Operational Safety Program is found in Chapter 11.0 of HNF-11724. No exceptions are taken to the key attributes as described in HNF-11724.

5.7 Fire Protection

The fire hazards are identified in the FHA (CP-45673) for this DSA. Activities authorized by this DSA will be performed consistent with the requirements of the site Fire Protection Program. Facility specific controls and recommendations are identified in the FHA. The Fire Protection Program is described in a portion of Chapter 11.0 of HNF-11724. The key attributes (KA) pertaining to fire protection, as described in HNF-11724 apply except for KA 11-5. There are no safety basis requirements for the deactivated facility fire suppression system. NFPA inspection, testing, and maintenance requirements are not applicable to this deactivated system.

5.8 Procedures and Training

The procedure development program employs a graded approach to ensure that work processes are controlled by approved instructions, procedures, design documents, technical standards, or other hazard controls adopted to meet regulatory or contractual requirements appropriate to the specific tasks to be performed. The training program provides employees, required to perform specified job requirements, with the training necessary to become qualified and maintain qualification. A description of the procedures development and training programs may be found in HNF-11724, Chapter 12.0. No exceptions are taken of the key attributes as described in HNF-11724.

5.9 Human Factors

Chapter 13.0 of HNF-11724 has no application to REDOX. As a facility in S&M and waiting final disposition, human factors have no design application.

5.10 Quality Assurance

CHPRC implements a Quality Assurance (QA) Program meeting the requirements of 10 CFR 830, Subpart A, "Quality Assurance Requirements," in accordance with PRC-MP-QA-599, *Quality Assurance Program*. The QA Program is described in Chapter 14.0 in HNF-11724. No exceptions are taken to the key attributes as described in HNF-11724.

5.11 Emergency Preparedness Program

CHPRC implements the DOE Emergency Management Plan through its Emergency Preparedness Program. The implementing organization prepares and maintains hazard assessments and response plans for applicable facilities. Facility staff is trained and practice drills are used to ensure a timely and effective response should an emergency occur. While the CP S&M Organization will perform drills annually, they will not be performed for every facility annually. The Emergency Preparedness Program is described in Chapter 15.0 of HNF-11724. No exceptions are taken to the key attributes as described in HNF-11724.

5.12 Management, Organization and Institutional Safety Provisions

The details of management, organization, and institutional safety policies are summarized in Chapter 17.0 of HNF-11724. No exceptions are taken to the key attributes as described in HNF-11724.

Chapter 6.0

References

6.0 References

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Appendix A

Hazard Evaluation

Contents

Tables

Appendix A
REDOX Facility Hazard Evaluation

A.1 Hazards Identification

The methodology used to identify hazards at the Reduction-Oxidation (REDOX) Facility is described in Section 3.3 of this Documented Safety Analysis (DSA). The hazard analyses that were previously in the *REDOX Facility Safety Analysis Report* (BHI-01142) were updated for this DSA. A hazard checklist and energy verification was prepared to verify the adequacy of the hazard identification and is provided in Table A-1. The hazard identification, which is provided in Table A-2, has six columns and summarizes the intrinsic hazards of the plant. The column headings and content are described in the following paragraphs.

A supplemental hazards analysis was conducted in 2015 to address remediation of the H-4 sample line. This supplemental hazards analysis drove the need for SAC C.5.3, "Flammable Atmosphere Control." See CP-58929 *REDOX H-4 Line Remediation Hazards Analysis* for full details.

Column 1. Hazard Type

This column identifies the type of hazard investigated. Hazard types investigated included the following: radioactive material, direct radiation, fissionable material, hazardous material (i.e., toxic, carcinogenic), biohazards, flammable/combustible material, reactive material, electrical energy, thermal energy, kinetic energy, and high pressure.

Column 2. Location

This column identifies the location investigated for the presence of the hazard type. Since the 202-S Canyon Building is relatively large, it was subdivided into specific process and operating areas (e.g., Canyon, operating gallery, Silo, etc.) for hazards identification purposes. Refer to Chapter 2.0, "Facility Description," for detailed information.

Column 3. Form

This column specifies the form of the hazard type. For example, the hazard type "hazardous material" is present in the 202-S Canyon Building Silo in the form of sodium hydroxide. Note that this column is not intended to provide a detailed identification of the chemical (e.g., oxide) or physical (e.g., crystalline) form of the hazard type. Such detail is not considered at the hazard identification stage of a safety analysis.

Column 4. Quantity

This column quantifies the form of the hazard type. Measured values are presented when relevant and available.

Column 5. Remarks

This column presents information that provides for a better understanding of the hazard type, location, form, and quantity.

Column 6. References

This column lists the information sources used to identify the location, form, and quantity of a given hazard type.

A.2 Hazards Evaluation

Evaluations documented in Table A-3 are applicable to the facility segments that contribute to the hazard classification of nuclear hazard category (HC) 3 or greater. Ancillary facilities that are less than the nuclear category 3 classification criteria are defined in Table 2-1 of this DSA and require no evaluation in this appendix. The methodology used to perform a preliminary evaluation of identified hazards is described in Section 3.3.2, "Hazard Analysis." The results of this methodology are presented in Table A-3.

The hazards evaluation associated with the H-4 sample line is contained in CP-58929 *REDOX H-4 Line Remediation Hazards Analysis*.

Table A-3 has twelve columns. The column headings and content are described in the following paragraphs.

Column 1. Item

This column sequentially numbers the table rows for ease of reference.

Column 2. Potential Event

This column identifies an event (e.g., fire) that, if it were to occur, could result in negative consequences to workers, the public, or the environment.

Column 3. Location

This column identifies the building (e.g., 202-S Canyon Building), or a specific location within a building (e.g., PR cage) impacted by the potential event. Refer to Chapter 2.0, "Facility Description," for detailed information.

Column 4. Hazard Type

This column identifies the type of hazard (e.g., radioactive material) that could negatively impact workers, the public, or the environment. Column entries are selected from Table A-2, as appropriate.

Column 5. Event and Possible Causes

This column describes the impact of the event at the location being evaluated and identifies possible causes. For example, a loss of electrical power caused by equipment failure can result in a loss of negative pressure differential and lead to the migration of contamination.

Column 6. Structures, Systems, and Components

This column identifies SSC(s) (e.g., sand filter) that potentially serve a preventive or mitigative function.

Column 7. Administrative

This column identifies administrative features (e.g., emergency procedures) that potentially serve a preventive or mitigative function.

Column 8. "C"

This column identifies the consequence ranking assigned to the event that assumes no mitigative or preventive controls.

Column 9. "F"

This column identifies the frequency ranking assigned to the event that assumes no mitigative or preventive controls.

Column 10. Risk Bin Values and Selection for Additional Analysis

This column identifies the applicable risk value and indicates (e.g., yes/no) if the event has been selected for additional evaluation/accident analysis.

Column 11. Hazard Beyond Standard Industrial Hazard

This column indicates (e.g., yes/no) if the hazards posed by the potential event are beyond those found in standard industrial settings.

Column 12: Comments

This column provides rationale for determining if the hazard is a standard industrial hazard and acknowledges the role of the safety management programs.

Table A-1. REDOX Facility Hazard Identification Checklist and Energy Verification

REDOX, Hazard Identification Checklist and Energy Designators								
LOTE Low Thermal Energy			**AE Acoustic Energy**			**BIO Biological**		
☐	1	Cryogenic Systems	☒	1	Equipment/Platform Vibration	☒	1	Animal/Insect Hazard
☐	1.1	Freeze Seal Equipment	☒	2	Equipment Rooms	☒	1.1	Dead Animals
☒	1.2	Liquid N_2 in Dewars	☐	2.1	Motor Rooms	☒	1.2	Animal Droppings
☐	1.3	Liquid N_2 in Tanks	☐	2.2	Pump Rooms	☒	1.3	Animal Bites
☐	1.4	Liquid N_2 Production	☒	2.3	Fan Rooms	☒	1.4	Insect Bites
☐	1.5	Other Cryogenic Systems	☒	2.4	Compressor Rooms	☒	1.5	Insect Stings
☒	2	Low Ambient Temperatures	☐	2.5	Other Equipment Rooms	☒	2	Plant Hazards
☒	2.1	Loss of HVAC [system impacts]	☒	3	Decontamination & Size Reduction Tools	☒	2.1	Allergens (Dust)
☒	2.2	Loss of HVAC [worker impacts]	☒	3.1	Cutting Devices	☒	2.2	Toxins
☐	2.3	Freezers/Chillers	☒	3.2	Decontamination Devices	☒	3	Disease Related Hazards
☐	2.4	Other Low Temperatures	☒	3.3	Abrading Devices	☒	3.1	Bacteria
☐	3	Other LOTE Hazards	☐	3.4	Other AE Tools	☒	3.2	Viruses
			☐	4	Other AE Hazards	☐	3.3	Sewage
						☐	3.4	Blood/Body Fluids
						☐	3.5	Medical Waste
						☐	4	Other BIO Hazards

Table A-1. REDOX Facility Hazard Identification Checklist and Energy Verification

NPH Natural Phenomena		
☒	1	Earthquakes
☒	2	Natural Radiation
☒	3	Lightning
☒	4	Solar/Heat Wave
☒	5	Range Fire
☒	6	Dust/Sand
☒	7	Fog
☒	8	Heavy Rain
☒	8.1	Flooding [from rain]
☐	8.2	Sediment Transport
☒	9	Hail
☒	10	Low Temperatures
☒	11	Freeze
☒	12	Heavy Snow
☒	13	High Winds
☐	14	Tornadoes
☐	15	Volcanoes
☒	16	Volcanic Ash
☐	17	Other NPH

OTH Other		
☒	1	Inert/Low O_2 Atmosphere
☒	1.1	Dust [breathing]
☒	1.2	N_2/He Atmosphere
☒	1.3	Confined Spaces
☒	1.3.1	Tanks
☐	1.3.2	Basins
☒	1.3.3	Manholes
☒	1.3.4	Pits
☒	1.4	Trench/Excavation Collapse
☒	1.5	Water in Confined Space
☐	1.6	Other Low O_2 Atmospheres
☒	2	Inadequate Visibility
☒	2.1	Respirator Fogging
☒	2.2	Dust [visibility]
☒	2.3	Glare
☐	2.4	Other Impaired Visibility
☒	3	External/Offsite Event
☒	3.1	Aircraft Crash
☐	3.2	Offsite Transportation Accident
☐	3.3	Offsite Explosion
☒	3.4	Major Fire
☐	3.5	Reservoir Failure
☐	3.6	Other External Event
☒	4	Unknown Material
☒	5	Unknown Configuration
☐	6	Other OTH Hazards

KE Kinetic Energy		
☒	1	Vehicle/Transport Devices in Motion
☐	1.1	Rail Cars/Trains
☒	1.2	Excavators/Backhoes
☒	1.3	Cranes/Crane Loads
☒	1.4	Trucks/Cars
☒	1.5	Forklifts/Loaders
☐	1.6	Conveyors
☒	1.7	Man-Powered Devices in Motion
☒	1.7.1	Hoists
☒	1.7.2	Carts/Dollies
☐	1.8	Other Device in Motion
☒	2	Loaded Transports in Motion
☒	2.1	Crane Loads [loaded]
☒	2.2	Trucks [loaded]
☒	2.3	Forklifts [loaded]
☐	2.4	Conveyors [loaded]
☒	2.5	Loaded Man-Powered Transports in Motion
☒	2.5.1	Hoists [loaded]
☒	2.5.2	Pallet Jacks [loaded]
☒	2.5.3	Carts/Dollies [loaded]
☐	2.6	Other Transport in Motion
☒	3	Decontamination & Size Reduction Tools
☒	3.1	Impact Tools
☒	3.2	Projectile Tools
☐	3.3	Other KE Tools
☐	4	Relief Valve Blow-down
☐	5	Other KE Hazards

Table A-1. REDOX Facility Hazard Identification Checklist and Energy Verification

	LOEE	Loss of Electrical Energy
☒	1	Loss of Powered Equipment
☒	1.1	Motor Stoppage
☒	1.2	Pump Stoppage
☒	1.3	Fan Stoppage in Areas with Differential Pressure
☒	1.3.1	Flow Reversal
☐	1.3.2	Supply Fan Pressurization
☐	1.3.3	Static Air Situation
☒	1.4	Fan Stoppage in Ventilated Areas
☒	1.4.1	Accumulation of Hazardous Vapors
☒	1.4.2	Accumulation of Asphyxiants
☒	1.4.3	Accumulation of Flammable Gases
☐	1.5	Compressor Stoppage
☐	1.5.1	Loss of Air [dry-pipe]
☐	1.5.2	Loss of Air [no inert]
☐	1.5.3	Reduced PPE Pressure
☒	1.6	Loss of Heaters
☒	1.6.1	System Freeze Impacts
☒	1.6.2	Worker Freeze Impacts
☐	1.7	Loss of Coolers/Chillers
☐	1.7.1	System Overheat Impacts
☐	1.7.2	Worker Overheat Impacts
☐	1.8	Misdirected Flow due to Loss of Valves/Dampers
☐	1.9	Loss Instrumentation
☐	1.10	Other Equipment Loss
☒	2	Inadequate Light/Illumination
☒	2.1	Operations Impacts
☒	2.2	Worker Impacts
☒	3	Loss of Batteries/Direct Current Systems
☐	4	Other LOEE Hazards

	CM	Chemical Materials
☒	1	Toxins
☐	1.1	Hepatotoxins [Carbon Tetrachloride]
☐	1.2	Nephrotoxins [Chloroform]
☒	1.3	Neurotoxins [Mercury]
☒	1.4	Reproductive Toxins [Lead]
☐	1.5	Toxic Agents [Strychnine]
☒	1.6	Agents that Attack the Lungs [Asbestos]
☒	1.6.1	Ceiling Tiles/Insulation
☒	1.7	Agents that Attack the Skin [Acetone]
☒	1.8	Agents that Attack the Eyes [Organic Solvents]
☐	1.9	Agents that Attack the Mucous Membranes [Ammonia]
☒	1.10	Agents that Attack the Blood [Carbon Monoxide/ Cyanides]
☒	1.11	Carcinogens [Carbon Tetrachloride, PCBs]
☒	1.12	Sensitizers [Beryllium/Epoxy Resins]
☐	1.13	Irritants [Calcium Chloride]
☒	1.14	Pesticides/Insecticides
☒	1.15	Herbicides
☐	1.16	Other Toxins
☐	2	Asphyxiants
☒	3	Miscellaneous Chemicals/Groups
☒	3.1	Hazardous Wastes [RCRA, TSCA]
☐	3.2	Creosote
☒	3.3	Other Miscellaneous Chemicals
☐	4	Other CM Hazards

	CE	Chemical Energy
☒	1	Oxidizers
☐	1.1	Organic Peroxides
☒	1.2	Corrosives/Acids/Reagents/ Bleaches [in use] (Spray for biological)
☒	1.3	Residual Corrosives/Acids
☒	1.4	Battery
☐	1.5	Other Oxidizers
☐	2	Reactives
☐	2.1	Water Reactives [Sodium]
☐	2.2	Shock Sensitive Chemicals [Nitrates]
☒	2.3	Peroxides/ Superoxides/Ethers
☐	2.4	Explosive Substances
☐	2.4.1	Electric Squibs
☐	2.4.2	Dynamites/Caps/ Primer Cord
☐	2.4.3	Dusts [explosive]
☐	2.5	Other Reactives
☒	3	Other Chemical Energy Hazards
☒	3.1	Corrosion/Oxidation [rust]
☒	3.2	Bonding Agents
☒	3.2.1	Sealants/Fixatives
☒	3.2.2	Epoxies/Adhesives
☒	3.3	Refrigerants/Coolants [Propylene Glycol]
☐	3.4	Water Treatment Products
☒	3.5	Decontamination Chemicals
☒	3.6	Miscellaneous Laboratory Chemicals
☐	3.7	Soil/Air/Water Reactions [Buried Materials]
☒	4	Incompatible Wastes
☐	5	High Temperature Wastes
☐	6	Other CE Hazards

Table A-1. REDOX Facility Hazard Identification Checklist and Energy Verification

ME Mechanical Energy	TP Thermal Potential Energy	EE Electrical Energy
☒ 1 Transverse [single direction] Motion Devices	☒ 1 Flammable Gases	☒ 1 High Voltage Equipment
☒ 1.1 Forklift Tines [puncture]	☒ 1.1 Natural Gas/Propane (Fork Lift)	☒ 1.1 Power Transmission Equipment
☐ 1.2 Piston Compressors [crush]	☒ 1.2 Welding/Cutting Gases	☒ 1.1.1 Wiring [high voltage]
☐ 1.3 Presses [crush]	☐ 1.3 Laboratory/Calibration Gases	☒ 1.1.2 Overhead Transmission Lines
☒ 1.4 Pinch Points [pinch]	☐ 1.3.1 Methane/Butane	☒ 1.1.3 Transformers [high voltage]
☒ 1.5 Sharp Edges/Objects [cut]	☐ 1.3.2 H_2 [lab]	☐ 1.1.4 Switchgear [high voltage]
☒ 1.6 Drills [puncture]	☒ 1.4 Process/Reaction Off-Gases	☐ 1.2 Capacitor Banks
☒ 1.7 Sanders/Brushes [wear]	☒ 1.4.1 H_2 [containers]	☐ 1.3 Lightning Grids
☒ 1.8 Shears/Pipe Cutters [shear]	☒ 1.4.2 H_2 [process]	☐ 1.4 Other High Voltage Hazards ____
☒ 1.9 Grinders [crush/pinch/shear]	☐ 1.4.3 Sewer Gas	☒ 2 Low Voltage Equipment
☐ 1.10 Other Transverse Motion ____	☒ 1.4.4 Carbon Monoxide	☒ 2.1 480/240/120 Volt Equipment
☒ 2 Reciprocating [back and forth] Motion Devices	☒ 1.5 Other Flammable Gases _Hexone____	☒ 2.1.1 Wiring [low voltage]
☒ 2.1 Vibration [wear]	☒ 2 Flammable/Combustible Liquids	☒ 2.1.2 Cable Runs
☒ 2.2 Saws [cut]	☒ 2.1 HEPA Test Aerosol Fluid	☒ 2.1.3 Overhead Wiring
☐ 2.3 Other Reciprocating Motion ____	☒ 2.2 Petroleum Based Products	☒ 2.1.4 Underground Wiring
☒ 3 Circular Motion Devices	☒ 2.2.1 Gasoline	☒ 2.1.5 Transformers [low voltage]
☒ 3.1 Belts/Hoist Cables [pull/wrap]	☒ 2.2.2 Diesel Fuel	☒ 2.1.6 Switchgear [low voltage]
☒ 3.2 Bearings/Shafts [wrap]	☒ 2.2.3 Oils [lube, coolant]	☒ 2.1.7 Service Outlets
☒ 3.3 Gears/Couplings [pull]	☒ 2.2.4 Grease	☐ 2.1.8 Other Electrical Equipment ____
☐ 3.4 Diesel Generators/ Turbines [wrap]	☒ 2.3 Vehicle/Equipment Fuel Tanks	☒ 2.2 Temporary Power Equipment
☒ 3.5 Pumps [wrap]	☒ 2.3.1 Gasoline [tank]	☒ 2.2.1 Diesel Units
☒ 3.6 Fans [wrap]	☒ 2.3.2 Diesel Fuel [tank]	☐ 2.2.2 Battery Banks
☐ 3.7 Rotary Compressors [wrap]	☒ 2.4 Paint/Cleaning/ Decontamination Solvents	☒ 2.2.3 12-32 VDC Systems
☐ 3.8 Centrifuges [wrap]	☒ 2.5 Paints/Epoxies/Resins	☒ 2.2.4 Other Temporary Electrical ____
☒ 3.9 Drills/Rotary Sanders [wrap]	☐ 2.6 Other Flammable Liquids ____	☒ 2.3 Electrical Equipment [low voltage]
☒ 3.10 Grinders [wrap]	☒ 3 Combustible Solids	☒ 2.3.1 Motors
☐ 3.11 Other Circular Motion ____	☒ 3.1 Paper/Wood Products	☒ 2.3.2 Pumps
☐ 4 Other ME Hazards ____	☒ 3.2 Cloth/Rags	☒ 2.3.3 Fans
	☒ 3.3 Rubber	☒ 2.3.4 Compressors
	☒ 3.4 Plastic Materials	☒ 2.3.5 Heaters
	☒ 3.4.1 Size Reduction Tents/ Permacons	☒ 2.3.6 Valves/Dampers
	☒ 3.4.2 Benelex/Lexan/HDPE	☒ 2.3.7 Power Tools
	☒ 3.4.3 Rigid Liners/Poly-Liners/ Bagging Materials	☒ 2.3.8 Instrumentation
	☐ 3.5 Other Combustible Solids ____	☐ 2.3.9 Other Electrical Use Equipment ____
		☐ 2.4 Grounding Grids
		☒ 2.5 Static Charge
		☐ 2.6 Other Low Voltage Hazards ____

Table A-1. REDOX Facility Hazard Identification Checklist and Energy Verification

PE Potential Energy	PE Potential Energy (cont'd)	PE Potential Energy (cont'd)
☒ 1 Pressure-Related PE Hazards	☒ 2 Gravity-Related PE Hazards	☒ 3 Momentum-Related PE Hazards
☒ 1.1 Compressed Gases	☒ 2.1 Elevated Equipment/Structures	☒ 3.1 Moving Vehicle/Transport Devices
☒ 1.1.1 Breathing Air/Compressed Air/O_2	☒ 2.1.1 Cranes/Hoists	☐ 3.1.1 Rail Cars/Trains [in motion]
☒ 1.1.2 He/Argon/Specialty Gases	☒ 2.1.2 Ducting/Lights/Piping	☒ 3.1.2 Cranes [in motion]
☒ 1.1.3 Refrigerants/CO_2 Bottles	☒ 2.1.3 Rollup Doors	☒ 3.1.3 Trucks [in motion]
☒ 1.1.4 Other Bottled Gases	☒ 2.1.4 Elevators	☒ 3.1.4 Forklifts/Loaders [in motion]
☐ 1.1.5 Gas/Air Receivers/ Compressors	☒ 2.1.5 Roofs/Plenums	☐ 3.1.5 Other Moving Materials ____________
☒ 1.1.6 Other Compressed Gas ____________	☒ 2.1.6 Upper Floor Components	☒ 3.2 Rotating Equipment
☒ 1.2 High Pressure Gas Systems	☒ 2.1.7 Tanks/Solutions in Elevated Equipment	☒ 3.2.1 Bearings/Rollers/Shafts
☐ 1.2.1 Pressure Vessels	☐ 2.1.8 Steam/Natural Gas Lines	☒ 3.2.2 Gears/Couplings/Pivot Joints
☒ 1.2.2 Instrument/Plant Air	☒ 2.1.9 Power Lines/ Transformers	☒ 3.2.3 Diesel Generators/Turbines
☐ 1.2.3 Chemical Reaction Vessels/ Autoclaves	☒ 2.1.10 Other Elevated Equipment Elevated Table____	☒ 3.2.4 Pumps
☐ 1.2.4 Furnaces/Boilers	☒ 2.2 Elevated Hazardous Materials	☒ 3.2.5 Fans/Air Movers
☐ 1.2.5 Steam Header/Lines	☒ 2.2.1 Crane Loads	☒ 3.2.6 Rotary Compressors
☒ 1.2.6 Pneumatic Lines	☒ 2.2.2 Truck Loads	☐ 3.2.7 Centrifuges
☒ 1.2.7 Impact Tools	☒ 2.2.3 Forklift/Other Lifts Loads	☐ 3.2.8 Other Rotating Equipment ____________
☒ 1.2.8 Sand/CO_2 Blasting Equipment	☐ 2.2.4 Conveyor Loads	☐ 3.3 Other Momentum PE Hazards ____________
☐ 1.2.9 Other Pressurized Gas ____________	☒ 2.2.5 Hoist Loads	☐ 4 Other PE Hazards ____________
☒ 1.3 High Pressure Liquid Systems	☒ 2.2.6 Cart Loads	
☐ 1.3.1 Water Heaters	☒ 2.2.7 Hand Carried Loads	
☒ 1.3.2 Excavators/Backhoes [hydraulics]	☒ 2.2.8 Stacked Hazardous Materials	
☒ 1.3.3 Cranes [hydraulics]	☐ 2.2.9 Other Elevated Materials ____________	
☒ 1.3.4 Trucks/Cars [hydraulics]	☒ 2.3 Pits/Trenches/ Excavations	
☒ 1.3.5 Forklifts [hydraulics]	☒ 2.4 Elevated Work Surfaces	
☐ 1.3.6 Conveyors [hydraulics]	☒ 2.4.1 Roofs/Elevated Doors/Loading Docks	
☒ 1.3.7 Hydrolazing Equipment	☒ 2.4.2 Stairs/Elevators	
☒ 1.3.8 Tool Hydraulic Lines	☒ 2.4.3 Ladders/Fixed Ladders	
☒ 1.3.9 Solution Transfer Systems	☒ 2.4.4 Cherry-Pickers/Hysters	
☒ 1.3.10 Other Pressurized Liquids ____________	☒ 2.4.5 Scaffolding/Scissor Jack Scaffolds	
☒ 1.4 Pressurized Systems/ Components	☐ 2.4.6 Other Elevated Surfaces ____________	
☒ 1.4.1 Coiled Springs	☐ 2.5 Other Gravity PE Hazards ____________	
☒ 1.4.2 Stressed Members		
☒ 1.4.3 Torqued Bolts		
☒ 1.4.4 Gaskets/Seals/O'Rings		
☐ 1.4.5 Fire Suppression Systems		
☐ 1.4.6 Other Pressurized Systems ____________		
☒ 1.5 Vacuum Systems		
☐ 1.6 Other Pressure PE Hazards ____________		

Table A-1. REDOX Facility Hazard Identification Checklist and Energy Verification

RE Radiant Energy

☒	1	Direct Radiation Sources
☒	1.1	Calibration Sources
☒	1.2	Other Radioactive Material
☒	1.2.1	Fissile Material Storage/ Holdup
☒	1.2.2	Actinide Solutions
☒	1.2.3	Waste Containers (Generated Waste)
☒	1.2.4	Contamination
☐	1.3	Other Direct Radiation Hazards ________
☐	2	Ionizing Radiation Devices
☐	2.1	Radiography Equipment
☐	2.2	X-Ray Machines
☐	2.3	Electron Beams
☐	2.4	Ultra-Intense Lasers
☐	2.5	Accelerators
☐	2.6	Other Ionizing Hazards ________
☒	3	Non-Ionizing Radiation Sources
☐	3.1	Electromagnetic Sources
☐	3.1.1	Electromagnetic Communication Waves
☐	3.1.2	Radio-Frequency Generators
☐	3.1.3	Microwave Frequencies
☐	3.1.4	Electromagnetic Fields
☐	3.1.5	Electric Furnaces
☒	3.1.6	Computers
☒	3.2	Welding/Cutting Devices
☒	3.2.1	Plasma Arc Magnetic Field
☒	3.2.2	Plasma Arc Infrared/Ultraviolet Light
☒	3.2.3	Welding
☐	3.3	Low Power Lasers
☐	3.4	Other Non-Ionizing Hazards ________
☒	4	Potential RE Sources
☒	4.1	Critical Masses
☒	4.1.1	Solid Fissile Material
☒	4.1.2	Liquid Fissile Material
☒	4.1.3	Containerized Fissile Material
☒	4.2	Irradiated Equipment
☐	4.3	Other Potential RE Hazards ________
☐	5	Other RE Hazards ________

RM Radioactive Material

☒	1	Fissile Material [Metals/Oxides/Residues]
☒	1.1	Bag
☐	1.2	Glovebox [exposed]
☒	1.3	Can
☐	1.4	Welded Can
☒	1.5	Drum
☒	1.6	Overpack
☒	1.7	Type B Shipping Container
☒	1.8	Ducting [exposed]
☒	1.9	Plenum [exposed]
☒	1.10	Filter [exposed]
☐	1.11	Cooler
☒	1.12	Hood [exposed]
☐	1.13	Other Solid Fissile Material ________
☐	2	Actinide Solution
☐	2.1	Bottle
☐	2.2	Drum
☒	2.3	Piping
☐	2.4	Tank
☐	2.5	Other Liquid Fissile Material ________
☒	3	Waste [LLW, LLM, TRU, TRM]
☒	3.1	Bag
☐	3.2	Glovebox [exposed]
☒	3.3	Drum
☒	3.4	Metal Crate
☒	3.5	Pipe Overpack Container
☒	3.6	Overpack
☒	3.7	Shipping Cask/Sample Pig
☒	3.8	Ducting [exposed]
☒	3.9	Plenum [exposed]
☒	3.10	Filter [exposed]
☒	3.11	Hood [exposed]
☒	3.12	Wooden Crate
☒	3.13	Cargo Container
☒	3.14	Other Waste Material ________
☒	4	General Contamination
☒	4.1	Contaminated Soils
☒	4.2	Contaminated Water
☒	4.3	Contaminated Oil/Antifreeze
☐	4.4	Other Contamination ________
☐	5	Burial Grounds
☒	6	Other RM Hazards _Material in tanks________

TE Thermal Energy

☒	1	Chemical Reactions
☐	2	Pyrophoric Material
☐	2.1	Plutonium/Uranium Metal
☐	2.2	Pyrophoric Chemicals
☐	2.3	Other Pyrophoric Material ________
☒	3	Spontaneous Combustion Material
☒	3.1	Petroleum Based Products
☒	3.2	Reactive Chemicals
☒	3.3	Nitric Acids/Organics
☒	3.4	Paint/Cleaning/ Decontamination Solvents
☒	4	Open Flame Sources
☒	4.1	Cutting Torches
☒	4.2	Welding Torches
☐	4.3	Laboratory Burners
☐	4.4	Other Open Flames ________
☒	5	Heating Devices/Systems
☐	5.1	Furnaces
☐	5.2	Boilers
☒	5.3	Heaters
☐	5.4	Hot Plates
☐	5.5	RTGs
☐	5.6	Other Heating Equipment ________
☒	6	Radioactive Decay
☒	7	High Temperature Items
☐	7.1	Lasers
☐	7.2	Incinerators/Fire Boxes
☒	7.3	Engine Exhaust Surfaces
☐	7.4	Steam Lines
☒	7.5	Electrical Equipment
☒	7.5.1	Electrical Wiring
☒	7.5.2	Portable Lamps/Lighting
☒	7.6	Welding/Cutting/Grinding Surfaces
☒	7.6.1	Plasma Arc Surfaces
☒	7.6.2	Welding Surfaces
☒	7.6.3	Grinder/Saw Surfaces
☒	7.7	Friction Heated Surfaces
☒	7.7.1	Belts [friction]
☒	7.7.2	Bearings [friction]
☐	7.7.3	Gears [friction]
☒	7.7.4	Power Tools [friction]
☒	7.7.5	Motors/Fans [friction]
☐	7.8	Other High Temperature Items ________
☒	8	High Ambient Temperature Areas
☒	8.1	Loss of Ventilation
☐	8.2	Areas Around Furnaces/Boilers
☒	8.3	Multiple Layers PPE
☐	9	Other TE Hazards ________

Table A-2. REDOX Facility Hazard Identification

Hazard Type	Location	Form	Quantity	Remarks	References
Radioactive Material	202-S Canyon Building: Canyon (including process cells, equipment and piping, and deck)	Mixed fission products, plutonium and americium in vessels and piping; also present as surface contamination; tank D-10 contains 968 gal and tank D-13 contains 2,530 gal of contaminated liquid waste (water).	9,000 Ci beta activity. 1,500 Ci alpha activity.	Attempts were made during deactivation to flush systems with nitric acid and water to remove residual contamination. Liquid level in tanks D-10 and D-13 dropping over time due to evaporation.	Historic assumption from SD-DD-FL-001, deactivation report; hazards identification workshop.
	202-S Canyon Building: PR cage (including sample hoods, equipment and piping)	Mixed fission products, plutonium and americium present within equipment and piping, also present as surface contamination.	840 Ci beta activity. 140 Ci alpha activity.	Of known quantities, majority of activity (i.e., 97%) present in E-16 and E-17 concentrators.	BHI-00994, facility staff interviews, hazards identification workshop.
	202-S Canyon Building: North sample gallery (excluding PR cage) and south sample gallery	Mixed fission products, plutonium and americium in hoods, ducting, and piping; also present as surface contamination.	Minor amounts, included in inventory estimates for Canyon.	Some contamination and airborne radiation areas.	Facility staff interviews, hazards identification workshop.
	202-S Canyon Building North and South Operating, Pipe, and Storage Galleries	Mixed fission products, plutonium and americium in equipment and piping; also present as surface contamination.	Minor amounts, included in inventory estimates for Canyon.	Some contamination and radiological buffer areas.	Facility staff interviews, hazards identification workshop.
	202-S Canyon Building: Silo (processing side only)	Mixed fission products, plutonium and americium present as surface contamination and inside equipment and piping.	Included in inventory estimates for Canyon.	The Silo contained solvent extraction columns used in plutonium separations processes; all columns remain in the Silo.	Facility staff interviews.

Table A-2. REDOX Facility Hazard Identification

Hazard Type	Location	Form	Quantity	Remarks	References
Radioactive Material (cont.)	202-S Canyon Building: Remote shop (east end of the Canyon at the cell floor level)	Mixed fission products, plutonium and americium present as surface contamination.	Minor amounts, included in inventory estimates for Canyon.	Area is designated as a surface contamination and airborne radiation area. Radiation area adjacent to sump in southwest corner. Significant contamination potentially present in decon hood (located in the outer decon room) and wind tunnel.	Facility staff interviews.
	202-S, D cell	Low-level radioactive liquid waste.	Tank D-10 approximately 420 gal Tank D-13 approximately 5560 gal	Waste transferred from 222-S and is uncharacterized.	Facility staff.
	291-S Exhaust Fan Building (including sand filter)	Mixed fission products; fissionable material.	Estimated 8,000 Ci beta activity. Estimated 340 Ci alpha activity (equivalent to 5.6 kg ^{239}Pu). Minor surface contamination in the soil around the filter building. Some contamination internal to the exhaust fans.	No data could be found to indicate the inventory of radioactive material in the sand filter. Estimates calculated used historic stack emission data and a filter efficiency of 99.95% (as a reference point, the T Plant sand filters contain 50 Ci alpha); building is designated as a radiological buffer area and the fans are posted as contamination areas.	Facility walk down; hazards identification workshop; and 0200W-CA-N0007. See Section 3.2

Table A-2. REDOX Facility Hazard Identification

Hazard Type	Location	Form	Quantity	Remarks	References
Radioactive Material (cont.)	291-S-1 stack	Mixed fission products, plutonium and americium present as surface contamination.	Minor levels of fixed contamination.	Stack routinely washed during operations, top 100 ft of stack lined with stainless steel, stack equipped with a record sampler and beta/gamma monitors.	Hazards evaluation workshop.
	292-S Control and Jet Pit House Building	Mixed fission products, plutonium and americium present as surface contamination and contaminated liquid waste (water).	4 Ci beta activity.	Seal pot is used for condensate collection from concrete encased lines, sand filter, and 291-S-1 stack; building lower level is posted as a contamination area and upper level is a radiological buffer area.	Historic assumption from SD-DD-FL-001, staff interviews.
	2904-SA Cooling Water Sampling Building	Mixed fission products, plutonium and americium present as surface contamination, and contamination in equipment.	Negligible-Minor levels.	Below-grade weir previously used for sampling/diversion of liquid waste. Currently posted as a contamination area.	Hazard evaluation workshop, facility interviews.
	293-S Nitric Acid Recovery and Iodine Backup Building	Mixed fission products, plutonium and americium present as surface contamination, and contamination in equipment.	4 Ci beta, 1 Ci Pu.	Upper level of building contains fiber filter media (which is contaminated from operational use) and is designated as a radiological buffer area; lower area contains exchange columns and is designated as a contamination area.	Historical assumption from SD-DD-FL-001, staff interviews.

Table A-2. REDOX Facility Hazard Identification

Hazard Type	Location	Form	Quantity	Remarks	References
Radioactive Material (cont.)	2711-S Stack Gas Monitoring Building	Mixed fission products, and plutonium and americium present within equipment.	Negligible-minor amounts from air sample collection.	Some areas of building are designated as contamination areas, other portions are radiological buffer areas.	Facility staff interviews, survey data.
	2715-S Storage Building	None.	None.	Facility cleaned in 1993	Hazards evaluation workshop, facility interviews.
	2718-S Sand Filter Sample Building	Mixed fission products, plutonium and americium present as surface contamination, and contamination in piping.	Minor contamination is assumed to remain.	Building is posted as a contamination and radiation area.	Facility staff interviews.
	276-S Solvent Handling Building	Mixed fission products, plutonium and americium; material is present in the form of surface contamination in the building, tanks, and piping.	Negligible-minor quantities.	Of the three tanks, most of the contamination is present in tank 276-S-0-2; surface contamination in the building is minimal; building is designated as a radiological buffer area.	Internal WHC memorandum from Decommissioning Engineering to hexone file (WHC 1989). Facility walk down.
	276-S hexone tanks	Mixed fission products, plutonium and americium; contamination is present in fixed and hardened residue.	Negligible-minor amounts of contamination was found in the sludge of the tanks.	Sludge was fixed and stabilized with grout for interim closure.	WHC-EP-0570, 0200W-US-N0217

Table A-2. REDOX Facility Hazard Identification

Hazard Type	Location	Form	Quantity	Remarks	References
Radioactive Material (cont.)	211-S liquid chemical storage tank farm	Mixed fission products present as surface contamination on surrounding soils.	Negligible quantities.	Tanks were emptied and flushed during deactivation; no known internal contamination; contaminated soils believed to have migrated into the tank farm from other surface contamination areas, two storage pits in tank farm used for radiation instrument calibration surveyed and no sources present.	Facility walk down; facility staff interviews.
	202-S column laydown trench	Mixed fission products, plutonium and americium.	Minor quantities present as surface contamination within the trench. Assay during 223-S preparation indicates < 1 gram Pu.	There are currently no columns in the trench. Leaks from columns during former transport and storage activities resulted in contamination of the trench; posted as a radiation area. Lead shielding installed in first portion of trench in 1990 to reduce exposures.	Facility staff interviews.
Direct Radiation	202-S Canyon Building Canyon (including process cells, equipment and piping, deck)	Mixed fission products present as surface contamination on/above deck, and in/on cells, vessels, and piping.	9,000 Ci beta activity. 1,500 Ci alpha activity.	Interior of process cells likely in high radiation area; however, the Canyon is not accessed during routine S&M activities. Canyon deck is posted as an airborne radiation area.	WHC-EP-0619, facility staff interviews.

Table A-2. REDOX Facility Hazard Identification

Hazard Type	Location	Form	Quantity	Remarks	References
Direct Radiation (cont.)	202-S Canyon Building: Remote shop (east end, cell floor level)	Mixed fission products present as surface contamination and contamination within equipment.	Minor amounts, included in inventory estimates for Canyon.	Area is designated as a radiation area based on dose rate measurements adjacent to sump in SW corner.	Facility staff interviews.
	202-S column laydown trench	Mixed fission products, plutonium and americium.	Minor quantities present as surface contamination within the trench.	Area is designated as a radiation area; dose rate could be due to shine from roll-up door at base of Silo or from contamination within trench. Lead shielding installed in first portion of trench in 1990 to reduce exposures.	Facility staff interviews.
Fissionable Material	202-S Canyon Building Canyon Canyon (including process cells, equipment and piping, deck)	^{239}Pu present in process cell equipment and piping and present as surface contamination.	1,500 Ci alpha activity.	Attempts were made during deactivation to flush systems with nitric acid and water to remove residual contamination.	Historic assumption from SD-DD-FL-001, deactivation report, hazards identification workshop.
	202-S Canyon Building PR cage (including sample hoods, equipment and piping)	^{239}Pu present in equipment and piping.	140 Ci alpha activity.	Majority of activity (i.e., 97%) present in E-16 and E-17 concentrators.	BHI-00994, facility staff interviews, hazards identification workshop.
	291-S Exhaust Fan Building (including sand filter)	^{239}Pu in sand filter.	Estimated inventory of 340 Ci alpha.	Material dispersed within sand filter matrix. Estimated inventory calculated using historic stack emission data and a filter efficiency of 99.95% (as a reference point, the T Plant sand filters contain 50 Ci alpha).	Facility walk down, hazards identification workshop, 0200W-CA-N0007.

Table A-2. REDOX Facility Hazard Identification

Hazard Type	Location	Form	Quantity	Remarks	References
Hazardous Material (e.g., toxic, carcinogenic)	202-S Canyon Building Canyon (including process cells, equipment and piping, deck)	Residues of former process chemicals and chemicals used for deactivation potentially present in process equipment (pipes and vessels) and as contaminants on surfaces from spills and leaks. Acetylene tetrabromide and mercury heels present in some deactivated instruments.	Residuals remaining following deactivation.	Equipment and piping flushed to remove residual contamination during deactivation; process chemicals include nitric acid, aluminum nitrate, ammonium fluoride, sodium hydroxide, and ammonium dichromate; chemicals used in deactivation (i.e., flushing) include permanganate, dilute nitric acid, oxalic acid.	WHC-EP-0619, hazards evaluation workshop.
	202-S Canyon Building Dissolver cells (A, B, and C cells), waste transfer lines, waste treatment cell (D cell)	Beryllium in process equipment and piping.	Trace quantities.	Small quantities of beryllium were used in the fabrication of fuel elements. Trace quantities of beryllium are conceivably present in the dissolver and waste processing cells and associated piping.	Staff interviews.
	202-S Canyon Building North and south pipe galleries	Sodium hydroxide.	Minor quantity.	Bulk removal of sodium hydroxide performed but lines and funnel drains not flushed.	WHC-EP-0619, staff interviews.
	202-S Canyon Building AMU section of Silo	Sodium hydroxide.	Residual quantities.	Bulk sodium hydroxide removed from AMU tanks but funnel drains and floor drains not flushed.	Staff interviews.

Table A-2. REDOX Facility Hazard Identification

Hazard Type	Location	Form	Quantity	Remarks	References
Hazardous Material (e.g., toxic, carcinogenic) (cont.)	202-S Canyon Building Service areas	Solvents and cleaners.	Minor quantities.	Placed in storage cabinet in southwest corner of office area.	Staff interviews.
	276-S Solvent Handling Building	None.	None.	Facility deactivation (triple flushing) removed bulk materials; the effectiveness of the flushing was determined to be high when some tanks were re-opened and sampled, tanks are confirmed empty.	WHC-EP-0619 and WHC (1989).
	276-S hexone Tanks	Residual solids.	Unknown. Assumed to be 250 gal of distillation sludge and 30 gal hexone-contaminated liquid.	Remaining material following distillation and removal of 35,000 gal of mixed-waste hexone solvents. Testing indicates residual hazard remains. Material is grouted.	0200W-US-N0217-02.
	211-S liquid chemical storage tank farm	Residual process chemicals in piping and equipment.	Residual volumes are unknown but very small.	Facility deactivation removed bulk materials; process chemicals include nitric acid, aluminum nitrate, ammonium fluoride, sodium hydroxide, and ammonium dichromate.	Facility walk down.

Table A-2. REDOX Facility Hazard Identification

Hazard Type	Location	Form	Quantity	Remarks	References
Hazardous Material (e.g., toxic, carcinogenic) (cont.)	REDOX Facility All buildings (except 2715-S and 2710-S)	Asbestos insulation, friable if degraded or damaged.	Unknown quantities	Asbestos abatement program was carried out with stabilization of existing asbestos for 202-S Canyon Building galleries and office areas, 276-S, and 211-S tank farm piping and, ongoing equipment annual assessment performed.	BHI-00066, WHC-EP-0619, facility walk down.
	REDOX Facility: All buildings	Lead-based paint.	Not quantified.	None.	Staff interviews.
Biohazard	REDOX Facility: All buildings	Rodents, insects, snakes; bird and animal feces.	Greater activity than normally occupied facilities.	Because there is very little human activity in and around the REDOX Facility, increased rodent, insect and snake activity can be expected.	WHC-EP-0619.
Flammable/ Combustible Material	202-S Canyon Building: Canyon (including process cells, equipment and piping, deck)	Wooden box.	One wooden jumper storage box on Canyon deck per FHA (CP-45673).	Assessed as negligible to low.	See FHA (CP-45673).
	202-S Canyon Building: PR cage	PMMA.	See PR cage fire evaluation.	Walls of cage.	See PR cage fire evaluation (CP-45673).
	202-S Canyon Building Galleries and service areas	Transient loading.	See FHA (CP-45673).	Assessed as negligible to low.	See FHA (CP-45673).
	202-S Canyon Building: Silo	Potentially PCB-contaminated mineral oil contained in lead glass windows.	Total of 17 mineral oil-filled viewing windows located between 5 levels of AMU.	See FHA (CP-45673).	See FHA (CP-45673).

Table A-2. REDOX Facility Hazard Identification

Hazard Type	Location	Form	Quantity	Remarks	References
Flammable/ Combustible Material (cont.)	291-S Exhaust Fan Building	Oils and greases.	See FHA (CP-45673).	See FHA. (CP-45673)	See FHA (CP-45673); hazard evaluation workshop
	292-S Control and Jet Pit House Building	--	Negligible.	None.	Facility walk downs.
	293-S Nitric Acid Recovery and Iodine Backup Building	--	Negligible.	None.	Facility walk downs.
	276-S Solvent Handling Building	--	Negligible.	None.	Facility walk down.
	211-S Tank Farm	--	Negligible.	None.	Facility walk down.
Reactive Material	202-S Canyon Building	Residual process and deactivation chemicals within process piping/equipment.	Residual quantities.	Residual quantities of chemicals exist in separate process piping/equipment that, if mixed, could generate heat/gas (e.g., residues of nitric acid and sodium hydroxide).	Hazards evaluation workshop.
Electrical Energy	REDOX Facility: All buildings	None outside that routinely encountered in industry.	None outside that routinely encountered in industry.	Electrical system is designed/defined/ controlled for S&M activities (e.g., lock and tag), electricity as fire initiator evaluated in FHA, CP-45673	See FHA (CP-45673); staff interviews.
Thermal Energy	202-S Canyon Building Service areas	Space heaters.	Quantity of temporary heaters listed in work package.	None.	Hazard evaluation workshop.
	291-S Exhaust Fan Building (outside)	Diesel generator.	None outside that routinely encountered in industry.	None.	Hazard evaluation workshop.

Table A-2. REDOX Facility Hazard Identification

Hazard Type	Location	Form	Quantity	Remarks	References
Kinetic Energy	REDOX Facility All buildings	Structural components.	Not applicable.	Facilities occupied only infrequently during S&M activities.	Facility walk down and staff interviews.
	202-S Canyon Building	Elevators, crane, miscellaneous rotating equipment.	None outside that routinely encountered in industry.	Industrial hazard.	Facility walk down and staff interviews.
	291-S Exhaust Fan Building	Rotating equipment (i.e., exhaust fans).	One fan runs during normal operation.	Industrial hazard.	Facility walk down and staff interviews.
	REDOX Facility: All buildings	Aircraft crash.	Not applicable.	Probability of such an event is extremely low.	Facility walk down and staff interviews.
	REDOX Facility: All building	Vehicle impact.	Not applicable.	Probability of such an event is low.	Facility walk down and staff interviews.
High Pressure	291-S Exhaust Fan Building	Compressed air.	None outside that routinely encountered in industry.	Air compressor located in the 291-S Building.	Hazards evaluation workshop and update from operations staff.
	202-S Canyon Building	P-10 gas (10% methane in argon).	None	P-10 gas was used in gas proportional radiation detectors (i.e., hand/foot counters) located at select entry/exit points. (removed from service)	Hazards evaluation update from operations staff.

AMU aqueous makeup unit
FHA Fire Hazards Analysis
PCB polychlorinated biphenyl
PMMA polymethyl methacrylate
PR product receiver
S&M surveillance and maintenance
WHC Westinghouse Hanford Company

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
	Natural Phenomena										
1.	Seismic Event	202-S Canyon Building	Radioactive material, toxic material, kinetic energy	Damage results in structural failure of 202-S Canyon Building results in a loss of confinement and ventilation. Shock/vibration and movement of structure/equipment suspends hazardous materials resulting in an uncontrolled release to the environment.	Building structure, cell cover blocks.	S&M to support SSCs, Access Control, Restrict coverblock removal, Configuration Management, Radioactive and Hazardous Waste Management, Emergency Preparedness Program	L	U	III, Yes	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
2.	Seismic Event	291-S Exhaust Fan Building, sand filter, and 291-S-1 stack	Radioactive material, toxic material, kinetic energy	Structural damage results in a loss of confinement and loss of ventilation for 202-S Canyon Building. Structure met UBC at time of construction. Possible collapse of stack and collapse of sand filter cover blocks. Shock/vibration and movement of structure/equipment suspend hazardous substances resulting in an uncontrolled release to the environment.	Building structure, sand filter cover and below grade configuration.	S&M to support SSCs, Configuration Management, Radioactive and Hazardous Waste Management, Emergency Preparedness Program	L	U	III, Yes (consequences summed with 202-S seismic event)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
3.	Seismic Event	292-S Control and Jet Pit House Building	Radioactive material, toxic material, kinetic energy	Capability of facility to resist seismic ground motions unknown. Possible structural damage and breach of piping with associated release of residual hazardous material. Assume structure met UBC at time of construction. Possible leakage of contaminated liquid to soil column via seismic-induced cracks in pit.	Sump and pit structure.	S&M to support SSCs, Configuration Management, Radioactive and Hazardous Waste Management, Emergency Preparedness Program	L	U	III, No (bounded by 202-S)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.
4.	Seismic Event	293-S Nitric Acid Recovery and Iodine Backup Building	Radioactive, toxic material, kinetic energy	Capability of structure and equipment to resist seismic ground motions unknown. Possible structural damage and breach of scrubber and absorption columns and piping with associated release of residual hazardous material to the environment. Assume structure met UBC at time of construction. Possible causes: Large energy event	Building structure.	S&M to support SSCs, Configuration Management, Radioactive and Hazardous Waste Management, Emergency Preparedness Program	L	U	III, No (bounded by 202-S)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
5.	Seismic Event	2715-S Storage Building	Radioactive toxic material, kinetic energy	Capability of structure and equipment to resist seismic ground motions unknown. Possible structural damage. Assume structure met UBC at time of construction. Possible causes: Large energy event with waste accumulation	Building structure.	S&M to support SSCs, Configuration Management, Radioactive and Hazardous Waste Management, Emergency Preparedness Program	L	U	III, No (bounded by 202-S)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.
6.	Seismic Event	2711-S, Stack Gas Monitoring Building	Radioactive material, kinetic energy	Capability of structure and equipment to resist seismic ground motions unknown. Possible structural damage. Assume structure met UBC at time of construction. Possible causes: Large energy event	Building structure.	S&M to support SSCs, Configuration Management, Radioactive and Hazardous Waste Management, Emergency Preparedness Program	L	U	III, No (bounded by 202-S)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
7.	Seismic Event	2718-S	Radioactive material, kinetic energy	Capability of structure and equipment to resist seismic ground motions unknown. Possible structural damage. Assume structure met UBC at time of construction. Possible causes: Large energy event	Building structure.	S&M to support SSCs, Configuration Management, Radioactive and Hazardous Waste Management, Emergency Preparedness Program	L	U	III, No (bounded by 202-S)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.
8.	High Wind	202-S Canyon Building	Radioactive material, toxic material, kinetic energy	Failure of 202-S Canyon Building roof results in loss of confinement function for Canyon and galleries; active ventilation for all areas lost. (Note: little energy available to suspend hazardous material within the Canyon and only minor hazardous material are present in galleries.)	Building structure.	S&M to support SSCs, Configuration Management, Emergency Preparedness Program	L	U	III, No (bounded by seismic)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
9.	High Wind	291-S Exhaust Fan Building, sand filter, and 291-S-1 stack	Radioactive material, toxic material, kinetic energy	Capability of 291-S Exhaust Fan Building to resist high wind forces unknown; possible structural damage and release of radioactive material. Loss of ventilation for 202-S Canyon Building. Assume structure met UBC at time of construction	Building structure.	S&M to support SSCs, Configuration Management, Emergency Preparedness Program	L	U	III, No (bounded by 202-S)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.
10.	High Wind	292-S Control and Jet Pit House Building	Radioactive material, toxic material, kinetic energy	Capability of structure to resist high wind forces unknown. Possible damage to above-ground structure and breach of piping with associated release of residual radioactive/hazardous material. Assume structure met UBC at time of construction.	Building structure.	S&M to support SSCs, Configuration Management, Emergency Preparedness Program	L	U	III, No (bounded by 202-S)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.
11.	High Wind	293-S Nitric Acid Recovery and Iodine Backup Building	Radioactive material, toxic material, kinetic energy	Capability of structure to resist high wind forces is unknown. Possible damage to above- ground structure and breach of absorption columns/piping with associated release of residual radioactive/hazardous material. Assume structure met UBC at time of construction.	Building structure.	S&M to support SSCs, Configuration Management, Emergency Preparedness Program	L	U	III, No (bounded by 202-S)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
12.	High Wind	2711-S Stack Gas Monitoring Building	Radioactive material, kinetic energy	Capability of structure to resist high wind forces is unknown. Possible damage to above- ground structure. Assume structure met UBC at time of construction.	Building structure.	S&M to support SSCs, Configuration Management, Emergency Preparedness Program	L	U	III, No (bounded by 202-S)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.
13.	High Wind	2715-S Storage Building	Radioactive material, kinetic energy	Capability of structure to resist high wind forces is unknown. Possible damage to above- ground structure. Assume structure met UBC at time of construction.	Building structure.	S&M to support SSCs, Configuration Management, Emergency Preparedness Program	L	U	III, No (bounded by 202-S)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.
14.	High Wind	2718-S Sandfilter Sample Building	Radioactive material, kinetic energy	Capability of structure to resist high wind forces is unknown. Possible damage to above- ground structure. Assume structure met UBC at time of construction.	Building structure.	S&M to support SSCs, Configuration Management, Emergency Preparedness Program	L	U	III, No (bounded by 202-S)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
15.	Ash and/or Snow Loading	202-S Canyon Building	Radioactive material, toxic material, kinetic energy	It is assumed that 202-S Canyon Building roof fails under excessive ash and/or snow loading resulting in impacts to hazardous materials in Canyon and galleries.	Building structure.	S&M to support SSCs, Configuration Management, Emergency Preparedness Program	L	U	III, No (bounded by seismic)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.
16.	Ash and/or Snow Loading	291-S Exhaust Fan building, sand filter, and exhaust stack	Radioactive material, toxic material, kinetic energy	Capability of 291-S Building to resist ash and/or snow loading unknown. Possible damage to exhaust fans and loss of ventilation to 202-S Canyon Building. Weather cover over sand filter survives no impact.	Building structure.	S&M to support SSCs, Configuration Management, Emergency Preparedness Program	L	U	III, No (bounded by 202-S)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.
17.	Ash and/or Snow Loading	292-S Control and Jet Pit House Building	Radioactive material, toxic material, kinetic energy	Capability of structure to resist ash and/or snow loading unknown. Possible roof failure and breach of piping with associated release of radioactive/hazardous material.	Building structure.	S&M to support SSCs, Configuration Management, Emergency Preparedness Program	L	U	III, No (bounded by 202-S)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
18.	Ash and/or Snow Loading	293-S Nitric Acid Recovery and Iodine Backup Building	Radioactive material, toxic material, kinetic energy	Capability of structure to resist ash and/or snow loading unknown. Possible roof failure and breach of absorption column and scrubbers/piping with associated release of radioactive/hazardous material.	Building structure.	S&M to support SSCs, Configuration Management, Emergency Preparedness Program	L	U	III, No (bounded by 202-S)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.
19.	Ash and/or Snow Loading	2711-S Stack Gas Monitoring Building	Radioactive material	Capability of structure to resist ash and/or snow loading unknown. Possible roof failure and release of radioactive/hazardous material.	Building structure.	S&M to support SSCs, Configuration Management, Emergency Preparedness Program	L	U	III, No (bounded by 202-S)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.
20.	Ash and/or Snow Loading	2715-S Storage Building	Radioactive material	Capability of structure to resist ash and/or snow loading unknown. Possible roof failure and release of radioactive/hazardous material.	Building structure.	S&M to support SSCs, Configuration Management, Emergency Preparedness Program	L	U	III, No (bounded by 202-S)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
21.	Ash and/or Snow Loading	2718-S Sandfilter Sample Building	Radioactive material	Capability of structure to resist ash and/or snow loading unknown. Possible roof failure and release of radioactive/hazardous material.	Building structure.	S&M to support SSCs, Configuration Management, Emergency Preparedness Program	L	U	III, No (bounded by 202-S)	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required.
22.	Water Intrusion	202-S Canyon Building Canyon and galleries	Radioactive material, toxic material	Water intrusion into Canyon or galleries leads to spread of contamination. Possible causes: degradation of facility roof.	Building structure.	Surveillance procedures, spill response procedure	L	A	III, No (low consequence)	No	No significant consequences
23.	Water Intrusion	202-S Canyon Building PR cage	Radioactive material	Water intrusion into the PR cage leads to spread of contamination. Possible causes: water intrusion in Building 233-S process hood with subsequent flow to PR cage via interconnected drain lines.	Building structure, PR cage sump.	Surveillance procedures, spill response procedures	L	A	III, No (low consequence)	No	No significant consequences
24.	Water Intrusion	202-S Canyon Building, column laydown trench	Radioactive material	Water intrusion into trench leads to spread of contamination. Possible cause: local flooding, degradation of weather cover.	Weather cover, concrete-lined trench.	S&M. Surveillance procedures, spill response procedures	L	A	III, No (low consequence)	No	No significant consequences

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
25.	Water Intrusion	291-S Exhaust Fan Building, sand filter, and exhaust stack	Radioactive material	Water intrusion into sand filter leads to spread of contamination Radioactive material	Weather cover, sand filter sump/drain, 292-S pit level monitoring instruments.	Surveillance procedures, spill response procedures	L	A	III, No (low consequence)	No	No significant consequences
26.	Water Intrusion	292-S Control and Jet Pit House Building	Radioactive material	Water intrusion leads to spread surface contamination. Possible cause: building deterioration local runoff, squalls or heavy cloud burst.	Weather/ structural covers, sump.	Surveillance procedures, spill response procedures	L	A	III, No (low consequence)	No	No significant consequences
27.	Water Intrusion	293-S Nitric Acid Recovery and Iodine Backup Building	Radioactive material	Water intrusion leads to spread surface contamination. Possible cause: building deterioration local runoff, squalls or heavy cloud burst.	Weather/ structural covers, sump.	Surveillance procedures, spill response procedures	L	A	III, No (low consequence)	No	No significant consequences
28.	Water Intrusion	2711-S Stack Gas Monitoring Building	Radioactive material	Water intrusion leads to spread surface contamination. Possible cause: building deterioration local runoff, squalls or heavy cloud burst.	Weather/ structural covers, sump	Surveillance procedures, spill response procedures	L	A	III, No (low consequence)	No	No significant consequences

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
29.	Water Intrusion	2715-S Storage Building	Radioactive material	Water intrusion leads to spread surface contamination. Possible cause: building deterioration local runoff, squalls or heavy cloud burst.	Weather/ structural covers, sump	Surveillance procedures, spill response procedures	L	A	III, No (low consequence)	No	No significant consequences
30.	Water Intrusion	2718-S Sandfilter Sample Building	Radioactive material	Water intrusion leads to spread surface contamination. Possible cause: building deterioration local runoff, squalls or heavy cloud burst.	Weather/ structural covers, sump	Surveillance procedures, spill response procedures	L	A	III, No (low consequence)	No	No significant consequences

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
	External Events										
31.	Loss of Electrical Power	202-S Canyon Building	Radioactive material	Loss of electric power leads to the loss of negative pressure differentials in 202-S due to loss of exhaust fan in 291-S. Possible migration of surface contamination to the environment. Possible causes: loss of electrical feed to the facility, system or component failure within facility.	None	S&M to support SSCs, Access Control, Configuration Management, Radiation Protection	L	A	III, No	No	Risk to the FW is a standard industrial hazard since the dominant hazard is loss of electric power, which applies to all facilities (subsequent loss of confinement is addressed in Item 46). No additional controls beyond SMPs are required.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
32.	Loss of Electrical Power	291-S Exhaust Fan Building	Radioactive material	Loss of power leads to loss of exhaust fan resulting in a loss of negative pressure differentials in 202-S. Possible causes: loss of electrical feed to the facility, system or component failure within facility.	None	S&M to support SSCs, Access Control, Work Control, Configuration Management, Radiation Protection	L	A	III, No	No	Risk to the FW is a standard industrial hazard since the dominant hazard is loss of electric power, which applies to all facilities (subsequent loss of confinement is address in Item 46). No additional controls beyond SMPs are required.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
33.	Aircraft Impact	REDOX General Facility	Radioactive material, toxic material, kinetic energy	The probability of an aircraft impacting a REDOX structure is documented in CP-56944, *CP S&M Aircraft Impact Frequency Analysis: PUREX.*	None.	Hazardous Material Protection, Operational Safety (Fire Protection), Emergency Management Program	L	EU	IV, Yes	No	Building structure provides no mitigation for FW. No additional controls beyond SMPs are required. Building is maintained; no specific SMP to prevent aircraft impact.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
34.	Vehicle Impact	REDOX General Facility	Radio-logical, hazardous material, kinetic energy	Ground vehicle impacts Staged waste, and releasing residual chemicals in the drums or waste boxes. Initiator of waste fire. Possible causes: mechanical failure, vehicle operator error/incapacitation.	None	Work Control, Access Control, Hazardous Material program, SAC C.5.2 Waste Inventory Control	L	A	III, No (bounded by PR Cage and Waste Staging Fires)	No	Risk to the FW is a standard industrial hazard since the dominant hazard is vehicle impact, which applies to all facilities. No additional controls beyond the Waste Inventory Control SAC and SMPs are required.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
35.	Inadvertent Transfer	202-S Canyon Building Canyon	Radioactive material, toxic material	No process/transfer systems remain. Inadvertent transfer of tank farm tank waste to 202-S via 151-S/152-S diversion boxes. Possible causes: operator error identifying proper transfer route, operator error establishing proper transfer route (e.g., valve misalignment).	Transfer lines from tank farms blanked outside diversion boxes151-S, 152-S, building structure; jet transfer system deactivated.	Access and configuration of external pipelines are controlled by other RL contractors.	L	A	III, No (low consequence and not in scope of project operations)	No	No significant consequences

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
36.	Inadvertent Transfer	202-S Canyon Building Canyon	Radioactive material, toxic material	Inadvertent transfer from 222-S Laboratory via 219-S. Possible causes: operator error identifying proper transfer route, operator error establishing proper transfer route (e.g., valve misalignment).	Transfer line blanked at 222-S Laboratory; jet transfer system deactivated.	Access and configuration of external pipelines are controlled by other RL contractors.	L	A	III, No (low consequence and not in scope of Project operations)	No	No significant consequences
37.	Range Fire	REDOX General Facility	Radioactive material, toxic contamination	Range fire assumed to spread without response. Major inventories are confined by robust structures, soil and exposed surface contamination is assumed susceptible. Possible causes: Vehicle accident, vehicle fire, lighting strike, human error	Building structures.	S&M procedures, Operational Safety (Fire Protection), Emergency Preparation Program, SAC C.5.2 Waste Inventory Control	L	A	III, No (low consequence)	No	Risk to the FW is a standard hazard since the dominant hazard is fire, which applies to all facilities. No controls beyond the Waste Inventory Control SAC and the SMPs are required.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
	Internal/Operational Events										
38.	Fire	202-S Canyon Building process cell	Radioactive material, toxic material	Fire in process cell suspends radioactive/toxic materials present as surface contamination. Possible causes: inadvertent introduction of combustible materials and ignition source into process cell, where no access or crane operations are allowed.	None	Operational Safety (Fire Protection), S&M to support SSCs and work control, training	L	A	III, No (bounded by PR Cage and Waste Staging Fires)	No	Risk to the FW is a standard hazard since the dominant hazard is fire, which applies to all facilities. No controls beyond the SMPs are required.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
39.	Fire	202-S Canyon Building PR cage	Radioactive material, toxic material, flammable material	Transient combustibles accumulate in close proximity to PMMA windows and ignite. Fire suspends radioactive/toxic materials present as surface contamination within PR Cage. Possible causes: operator failure to remove combustibles, ignition of flammable gas inside process vessels or pipes during remediation. Possible ignition sources include electrical short, welding/cutting activities.	None	Operational Safety (Fire Protection), S&M to support SSCs and work control, training, restriction on open flame activities (e.g., welding and cutting), SAC C.5.3 Flammable Atmosphere Control	L	A	III, Yes	No	Risk to the FW is a standard hazard since the dominant hazard is fire, which applies to all facilities. No controls beyond SAC C.5.3 Flammable Atmosphere Control and the SMPs are required.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
40.	Fire	202-S Canyon Building Silo	Radioactive material, toxic material, flammable material	Mineral oil leaks from oil-filled Silo viewing windows and ignites. Burning oil and transient combustibles suspends radioactive/toxic materials. Possible causes: degradation of window seals, damage to window. Possible ignition sources include electrical short, welding/cutting activities.	None	Operational Safety (Fire Protection), S&M to support SSCs and work control, training, restriction on open flame activities (e.g., welding and cutting)	L	U	III, Yes	No	Risk to the FW is a standard hazard since the dominant hazard is fire, which applies to all facilities. No controls beyond the SMPs are required.
41.	Fire	Exterior Yard/ Facility	Radioactive material, toxic material, flammable material	Waste drums and or waste boxes are involved in a fire. Possible causes: operator error, equipment handling or vehicular accident, failure to follow procedures	None	Operational Safety (Fire Protection), Work control, Hazardous Material Protection, Radiation Protection, SAC C.5.2 Waste Inventory Control	L	A	III, Yes (control verification)	No	Risk to the FW is a standard hazard since the dominant hazard is fire, which applies to all facilities. No controls beyond the Waste Inventory Control SAC

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
											and the SMPs are required. FPE evaluated vehicle parking adjacent to concrete facilities and determined no separation distance required per NFPA 80A. Note: This scenario is also representative of a HC-3 structure fire.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
42.	Fire/ Explosion	276-S-141 and 276-S-142 tanks	Radioactive material, hazardous material, flammable	Spark or static discharge causes deflagration in one of the tanks, causing minor damage to tank and filter. Release of radioactivity and minor amounts of hexone. No longer applicable as tanks are fixed/stabilized with grout fill.	None	None	NA	NA	BHI 2002. 0200W-US-N0217-02	NA	NA
43.	Construction Equipment Impact	REDOX Canyon and gallery areas	Radiological, hazardous material, kinetic energy	Cranes or other large capacity equipment impacts the confinement barriers causing roof collapse onto Canyon floor or operating gallery. Possible causes: crane work at adjacent facilities	None	Work control, access control, Radiation Protection, equipment procedures, Operational Safety (hoisting and rigging manual)	L	A	III, Yes	No	Risk to the FW is a standard industrial hazard since the dominant hazard is impact, which applies to all facilities. No additional controls beyond SMPs are required.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
44.	Construction Equipment Impact	REDOX Sandfilter	Radiological, kinetic energy	Cranes of other large capacity equipment impact the cover and/or subgrade walls of the sandfilter. Possible causes: crane work at adjacent facilities, maintenance work to stack or ventilation system, equipment accidents related to waste management activities	None	Work control, access control, Hazardous Material Protection, Radiation Protection, equipment procedures, Operational Safety (hoisting and rigging manual)	L	A	III, Yes	No	Risk to the FW is a standard industrial hazard since the dominant hazard is impact, which applies to all facilities. No additional controls beyond SMPs are required.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
45.	Load Drop	202-S Canyon	Radiological, toxic kinetic energy	Drop of coverblock or other heavy pick onto Canyon deck/cell. Possible causes: Characterization of Canyon cells of contingency work required in cell areas.	Building Structure	Work control, access control, Hazardous Material Protection, Radiation Protection, equipment procedures, Operational Safety (hoisting and rigging manual)	L	A	III, Yes	No	Risk to the FW is a standard industrial hazard since the dominant hazard is a load drop, which applies to all facilities. No additional controls beyond SMPs are required.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
46.	Loss of Confinement	202-S Canyon Building	Radioactive material	Loss of ventilation as a result of loss of offsite power, mechanical failure, or air pressure results in a loss of confinement for the hazardous materials in the 202-S Canyon Building; see discussion under items 31 & 32 (loss of electric power). Note: This event has already occurred without a release, but the consequence rank assigned is bounding. Possible causes: External events, equipment failure, system maintenance	Building structure	S&M for SSCs, operating procedures, access control, radiation protection and work controls, training, configuration management	L	A	III, No	No	Risk to the FW is a standard hazard since the dominant hazard is loss of confinement, which applies to all facilities. No controls beyond the SMPs are required.
47.	Criticality	202-S Canyon Building PR cage, Silo, Canyon	Radioactive material, direct radiation	The potential for a criticality accident can only occur with simultaneous addition of moderator and redistribution of the fissionable material into a near optimum geometry.	None	Criticality Safety Program, HNF-36331, CHPRC-02595	H	BEU	III, No (See Criticality evaluation Section 5.1)	N/A	Not a credible event

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
48.	Criticality	291-S Exhaust Fan Building, sand filter, and exhaust stack	Radioactive material, direct radiation	Water intrusion inundates sand filter redistributing material and providing moderation leading to a criticality (assumes potentially critical mass/geometry present on filter). Possible cause: local flooding, degradation of sand filter weather cover.	None	Field verifications prior to intrusive activities, S&M of SSCs and work control, criticality safety, HNF-36331, CHPRC-02595	L	BEU	IV, No (See Criticality evaluation for FW Section 5.1)	N/A	Not a credible event
49.	Criticality	292-S Control and Jet Pit House Building	Radioactive material, direct radiation	Water intrusion into sand filter washes fissionable material into drain system, critical mass collects in 292-S drain seal tank. Possible cause: local flooding, degradation of sand filter weather cover.	None	Field verifications prior to intrusive activities, S&M of SSCs and work control, criticality safety, HNF-36331, CHPRC-02595	L	BEU	IV, No (See Criticality evaluation for FW Section 5.1)	N/A	Not a credible event
50.	Liquid Spray Release	292-S Control and Jet Pit House Building	Radioactive, hazardous material	Spray release of contaminated liquid during transfer from drain seal tank to receiver vessel (e.g., tank truck). Possible causes: transfer line failure, valve/fitting failure.	None	Work Control, Radiation Protection, Hazardous Material Protection	L	A	III, No Not selected for additional analysis due to very low activity (contaminated rain water condensate).	No	No significant consequences

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
51.	Liquid Spill	202-S, D cell	Low level radioactive liquid waste	Failure of tanks D-10 or D-13 causing a release into the cell. Degradation of tanks, handling accidents	None	Work control (cell access restricted), Access controls, Radiation Protection, USQ Program	L	A	III, No	No	Exposure to worker is not expected since cell entry is not authorized.
52.	Liquid Spill to Ground	292-S Control and Jet Pit House Building	Radioactive material, hazardous material	Spill of contaminated liquid to ground during transfer from drain seal tank to receiver vessel (e.g., tank truck). Possible causes: transfer line failure, valve/fitting failure, tanker overfills.	None	Work Control, Radiation Protection, Hazardous Material Protection	L	A	III, No	No	Radiation exposure is a hazard covered by SMPs. Exposure of this type would not meet the criteria for additional controls.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
53.	Container Spill	202-S Canyon Building	Toxic material	Chemical container fails or is manipulated such that its contents are spilled. Possible causes: degradation of container, human error, and container pressurization. Based on residual inventories and end user chemicals.	None	Work Control, Radiation Protection, Hazardous Material Protection	L	A	III, No	No	Risk to the FW is a standard hazard since the dominant hazard is a container spill, which applies to all facilities. No controls beyond the SMPs are required.
54.	Spread of External Surface Contaminants	All outdoor surface contamination	Radioactive material	Surface contamination is spread from designated areas. Possible causes: high winds; biological agents (birds, rodents, etc.).	None	Routine surveys and Radiation Protection controls (e.g., posting).	L	A	III, No	No	Radiation exposure is a hazard covered by SMPs. Exposure of this type would not meet the criteria for additional controls.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
55.	Explosion	202-S general, and waste accumulation/ staging area	Flammable material, radiological material	Accumulation hydrogen gases during waste treatment and packaging. Flammable gases in process vessels and piping. Possible causes: residual flammable chemicals from legacy operations, hydrogen generated from radiolysis reactions, characterization errors, non-compliance with procedures, damage to required breathing-filters	None	Work controls, Hazardous Material Protection, Operational Safety, Radioactive and Hazardous Waste Management, SAC C.5.2 Waste Inventory Control, SAC C.5.3 Flammable Atmosphere Control	L	A	III, Yes.	Yes	The concern to the FW is a deflagration which could cause serious injury or death; dose consequences to the FW are anticipated to be low. The risk is adequately protected by the Flammable Atmosphere Control SAC

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
56.	FW Exposure to External Radiation	General area; building and waste sites.	Radioactive material	FW resides in radiation or high radiation area for extended period of time. Possible causes: human error in surveying and/or posting of radiation or high radiation areas, radiation survey instrument failure.	Shielding from structure	S&M of SSCs, work control, Radiation Protection, access control	L	A	III, No	No	Radiation exposure is a hazard covered by SMPs. Exposure of this type would not meet the criteria for additional controls.
57.	FW Uptake of Radio-active Material	General area; building and waste sites.	Radioactive material	FW enters airborne radioactive material area or works in surface contamination area without proper personal protection equipment. Possible causes: human error in surveying and/or posting of surface contamination and/or airborne radioactive material areas.	None	S&M of SSCs, Radiation Protection, Hazardous Material Protection	L	A	III, No	No	Radiation exposure is a hazard covered by SMPs. Exposure of this type would not meet the criteria for additional controls.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments
58.	FW Exposure to Toxic Materials	202-S Canyon Building	Hazardous materials	Breach of process piping/equipment results in spread of residual quantities of process chemicals. Possible causes: corrosion, human error.	None	S&M of SSCs, work control, Hazardous Material Protection	L	A	III, No	No	Exposure to toxic materials is an industrial hazard covered by SMPs.
59.	FW Exposure to Toxic Materials	202-S Canyon Building Silo	PCBs	Breach of PCB-contaminated, oil-filled window results in spread of PCBs. Possible causes: degradation of window housing, operator error.	None.	S&M of SSCs, work control, Hazardous Material Protection	L	A	III, No	No	Exposure to toxic materials is an industrial hazard covered by SMPs.

Table A-3. REDOX Hazards Evaluation

Item	Hazard Summary				Preventative and/or Mitigative Features		Event Ranks		Risk Bin Values and Selection for Additional Analysis	Facility Worker	
	Potential Event	Location	Hazard Type from Table A-2	Event and Possible Causes	SSCs	Administrative	C	F		Hazard Beyond Standard Industrial Hazard	Comments

A	anticipated
BEU	beyond extremely unlikely
C	collocated worker
EU	extremely unlikely
F	frequency
FHA	Fire Hazards Analysis
FPE	Fire Protection Engineer
FW	facility worker
H	high
L	low
PCB	polychlorinated biphenyl
PMMA	polymethylmethacrylate
PR	product receiver
RL	U.S. Department of Energy, Richland Operations Office
S&M	surveillance and maintenance
SMP	Safety Management Program
SSC	structure, system, and component
U	unanticipated
UBC	Uniform Building Code
USQ	unreviewed safety question

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Appendix B

Reserved for Future Use

Appendix B
Reserved for Future Use

Appendix C

REDOX Technical Safety Requirements

Contents

Tables

Appendix C
REDOX Technical Safety Requirements

C.1 Use and Applications

This section contains basic information and instructions for using and applying the technical safety requirements (TSRs) and complies with the relevant sections of Title 10 CFR Part 830, *Nuclear Safety Management*, as implemented by CH2M HILL Plateau Remediation Company (CHPRC) agreements and procedures.

C.1.1 Acronyms

AC	ADMINISTRATIVE CONTROL
CHPRC	CH2M HILL Plateau Remediation Company
DOE	U.S. Department of Energy
DSA	documented safety analysis
ERDF	Environmental Restoration Disposal Facility
LCO	Limiting Condition for Operation
LEL	lower explosive limit
LLMW	low-level mixed waste
LLW	low-level waste
MAR	material at risk
REDOX	Reduction-Oxidation
RL	Richland Operations Office
RO/RO	roll-on/roll-off
S&M	surveillance and maintenance
SL	SAFETY LIMIT
SMP	safety management program
TRU	transuranic
TSR	technical safety requirement
USQ	unreviewed safety question

C.1.2 Definitions

NOTE: Defined terms in this list appear in uppercase type throughout these TSRs.

Term	Definition
ACTION	An ACTION statement describes the action or actions to be taken in the event a SAC element is not met. ACTION statements should be broken down whenever possible into separate statements describing a single deviated condition requiring operator action.
ACTIVITY/ ACTIVITIES	An ACTIVITY is the term representing the collection of tasks or steps commonly associated with a process.
ADMINISTRATIVE CONTROL (AC)	A provision relating to organization and management, procedures, record keeping, assessment, and reporting necessary to ensure safe operation of a facility.
DESIGN FEATURE	DESIGN FEATURES of the facility specified in the TSRs that, if altered or modified, would have a significant effect on safety operation.
IMMEDIATE/ IMMEDIATELY	Term used as a completion time for ACTION Statements when a step is to be initiated as soon as possibly achievable after discovery without creating a less stable condition and continuously and aggressively pursued until complete.
LIMITING CONDITION FOR OPERATION (LCO)	The lowest functional capability or performance levels of essential safety-related hardware.
LIMITING CONTROL SETTING (LCS)	Setting on safety systems that controls process variables to prevent exceeding SAFETY LIMITS.
NORMAL OPERATIONS	See Section C.1.3, "OPERATIONAL MODES."
OPERABLE/ INOPERABLE/ OPERABILITY	A system, subsystem, train, component, or device SHALL be operable or have OPERABILITY when it is capable of performing its specified function(s), and when all necessary attendant instrumentation, controls, electrical power, cooling or seal water, lubrication, or other auxiliary equipment that are required for the system, subsystem, train, component, or device to perform its function(s) are also capable of performing their related support function(s). See Section C.1.8, "General Principles of OPERABILITY."
OPERATING LIMITS	LIMITING CONTROL SETTING (LCS) and LIMITING CONDITION FOR OPERATION (LCO).
OPERATIONAL MODES	Operational modes for the Reduction-Oxidation (REDOX) Facility are NORMAL OPERATIONS. See Section C.1.3, "Operational Modes."

Term	Definition
SAFETY LIMIT (SL)	Limits on process variables associated with those physical barriers that are necessary for the intended facility function and are found to be required to guard against the uncontrolled release of radioactive and other hazardous materials.
SHALL	Denotes a mandatory requirement that must be complied with to maintain the requirements, assumptions, or conditions of the facility safety basis.
SURVEILLANCE REQUIREMENTS (SR)	Requirements related to testing, calibration, or inspection to ensure OPERABILITY of safety-related equipment and required support systems, or to ensure that operations are within the specified LCO.
TIME OF DECLARATION	The actual time when the facility manager or designee declares that a SAC or AC element is not met. As soon as possible upon notification of a problem, the problem should be evaluated and a declaration made by the facility manager or his designee if it is determined that a SAC or AC element is not met. Time specified for completion of ACTION is measured from the TIME OF DECLARATION unless otherwise specified within the ACTION Statement.
VIOLATION	See Section C.1.8, "TSR AC VIOLATION."

C.1.3 Logical Connectors

PURPOSE	The purpose of this section is to explain the use and application of logical connectors.
BACKGROUND	Logical connectors are used in TSRs to discriminate between (and yet connect) discrete conditions, ACTIONS, COMPLETION TIMES, SRs, and FREQUENCIES. The logical connectors include the "**<u>AND</u>**" and "**<u>OR</u>**." The physical arrangement of this connector on a page constitutes a specific meaning in accordance with the convention established in DOE G 423.1-1A.
USE OF LOGICAL CONNECTORS	Several levels of logic may be used to state ACTIONS. These levels are identified by the placement (or nesting) of the logical connectors and by the number assigned to each ACTION. The first level of logic is identified by the first digit of the number assigned to an ACTION and the placement of the logical connector in the first level of nesting (e.g., left-justified with the number of the ACTION). The successive levels of logic are identified by additional digits of the ACTION number and by successive indenting of the logical connectors.

When logical connectors are used to state a condition, usually only the first level of logic is used and the logical connector is left justified with the condition statement. For cases where successive levels of logic are used the lower level is identified solely by indenting the logical connector because subparts of a condition statement are not numbered separately.

DEFINITION OF LOGIC TERMS

The defined terms of this section appear in capitalized type, bolded, and underlined through-out the TSR document. ACTION statements are read top to bottom (e.g., a, b, c, d, etc.). A more detailed definition for logic connector interpretations for each TSR can be found in the Bases.

Term	Definition
AND	Used to connect two or more sets of criteria that must both (all) be satisfied for a given logical decision.
OR	Used to denote alternate combinations or conditions, meaning either one or the other criterion will satisfy a given logical decision.

C.1.4 Operational Modes

The operational condition and mode that applies to the REDOX Facility and its operations is defined as follows:

Term	Definition
NORMAL OPERATIONS	Surveillance and maintenance (S&M) ACTIVITIES are performed. The radioactive material inventory meets or exceeds the HC-3 threshold as defined in DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23.*

C.1.5 Completion Time

PURPOSE

The purpose of this section is to explain the use and application of COMPLETION TIMES.

BACKGROUND	The SPECIFIC ADMINISTRATIVE CONTROL conditions for which functional or performance requirements are not met, and the ACTION(s) that may be taken within a limited time (the COMPLETION TIME) or within a specified periodicity under these conditions. The ACTION statements provide interim remedial ACTION(s) or compensatory protection for the same safety concerns as the SAC while attempting to restore the functional capabilities or performance levels required by the SAC.
USE OF COMPLETION TIME	The COMPLETION TIME is the amount of time allowed to complete an ACTION. It is referenced to the TIME OF DECLARATION. If situations require entry into more than one condition within a single LCO or SAC ACTION (multiple conditions), the ACTION(s) for each condition SHALL be performed within the associated COMPLETION TIMES. When in multiple conditions, separate COMPLETION TIMES are tracked for each condition, starting from the TIME OF DECLARATION of the situation that required entry into the condition. Once a condition has been entered, subsequent discovery of subsystems, components, or variables that are inoperable or not within limits as a result of cascading effects from entering the condition SHALL <u>NOT</u> result in separate entry into the condition. The ACTION(s) of the condition continue to apply to each additional failure, and COMPLETION TIMES are based on initial entry into the condition. Entry into a SAC ACTION and SAC ACTION COMPLETION TIMES SHALL be documented.

C.1.6 Alternate Emergency Actions

Emergency actions may be taken in special circumstances. In an emergency, if a situation develops that is not addressed by the TSRs, staff members are expected to use their training and expertise, and applicable emergency response procedures to take actions to correct or mitigate the situation. Also, staff may take actions that depart from a requirement in the TSRs provided that the following conditions apply.

- An emergency situation exists.
- These actions are needed IMMEDIATELY to protect the public health and safety.
- No action consistent with the TSR can provide adequate or equivalent protection.

Such actions SHALL be approved, as a minimum, by the Facility Manager, or the Building Emergency Director. If emergency actions are taken, verbal notifications SHALL be made to the U.S. Department of Energy, Richland Operations Office (RL) facility representative as soon as practicable (10 CFR 830.205[b]).

C.1.7 AC Element Not Met

Deficiencies in a program or procedure non-compliances that indicate a programmatic breakdown significant enough to render the safety analysis invalid, or failure to comply with a Safety Management Program (SMP) key attribute is an AC element not met. Isolated discrepancies in a program or procedure do not, by themselves, constitute a TSR AC VIOLATION.

If an AC element is discovered not to have been performed or not have been followed, this would not necessarily result in a TSR AC VIOLATION. If failure to meet an AC element does not result in a TSR AC VIOLATION based on any one of the criteria listed in Table C-1, then this would be reported as a noncompliance with a hazard control (occurrence reporting severity category SC3). If the failure to meet an AC element results from any one of the criteria listed in Table C-1, then this constitutes a TSR AC VIOLATION and the steps in Section C.1.8 must be completed.

Table C-1. Criteria Constituting TSR AC VIOLATIONS

• A required program has not been established.
• The program has been established but the facility has not attempted to implement the program.
• Time frames or actions specified upon failure to meet an AC element are not met.
• Failure to comply with the program requirements specified in this document results in multiple recurrences of a specific key element not being met indicating a programmatic breakdown.

C.1.8 TSR AC VIOLATION

The following actions SHALL be taken in the event that a TSR AC VIOLATION occurs (this includes SACs):

1) Terminate affected ACTIVITY(ies) IMMEDIATELY except as necessary to achieve a safe configuration.
2) Take the following reporting actions:
   - 2.1) Make appropriate entries documenting the failure to meet the AC element(s) in the facility record, indicating any operational areas affected and restrictions imposed. Maintain the status of restrictions and operational areas affected in the facility as recovery progresses.
   - 2.2) Notify RL in accordance with DOE occurrence reporting requirements.
   - 2.3) Prepare an Occurrence Report and implement the corrective action management process, as required.
3) Restore administrative element within 10 working days.

4) If the AC element(s) cannot be restored within 10 working days, notify RL Facility Representative within the 10 working days and develop a facility-approved recovery plan and initiate actions of the recovery plan within the 10 working days.

Affected ACTIVITY(ies) may be resumed at any time when the relevant AC element(s) have been restored or as specified by the recovery plan.

C.1.9 General Principles of Operability

There are no LCOs. Therefore, principles of OPERABILITY are not required.

C.2 Safety Limits

The REDOX Facility has no SLs.

C.3 Limiting Conditions of Operations

The REDOX Facility has no LCOs.

C.4 Operating Limits and Surveillance Requirements

There are no OPERATING LIMITS identified for the REDOX Facility. There are no SURVEILLANCE REQUIREMENTS associated with administrative TSRs presented below.

C.5 Administrative Technical Safety Requirements

This section presents the ADMINISTRATIVE CONTROLS (ACs) for the REDOX Facility. The ADMINISTRATIVE CONTROLS are provisions relating to organization and management, procedures, record keeping, assessment, and reporting necessary to ensure the safe operation of the facility.

This section also identifies the SPECIFIC ADMINISTRATIVE CONTROLS (SACs) required with the issuance of DOE-STD-1186-2004, to provide increased attention and heightened assurance of effectiveness and reliability of the safety functions performed by the ACs designated as SACs.

The SACs identified in this section were designated based on their roles in the accident analyses in Section 3.4 of this DSA as being relied on in preventing and mitigating postulated accident scenarios. These SACs, along with the other programmatic ACs, SHALL be established, implemented, and maintained. Designation of SACs does not reduce the requirement for compliance with the other ACs in this TSR.

C.5.1 Safety Management Programs (AC)

C.5.1.1 Applicability

SMP applicability will be established, implemented, and maintained to ensure the overall safety function of an SMP is maintained through implementation of all applicable key attributes of the SMP identified in HNF-11724, *CH2M HILL Plateau Remediation Company Safety Management Programs*, as modified by Chapter 5.0 of this DSA. This AC applies to the planned activities (e.g., S&M and pre-demolition) until such time as the facility inventory is reduced and the facility can be re-categorized as less than a HC-3 nuclear facility.

C.5.1.2 Requirements

a. The following SMPs, as described in HNF-11724, SHALL be established, implemented, and maintained as applicable, unless otherwise noted in the DSA.

   - Prevention of Inadvertent Criticality*—as applicable per HNF-7098, *Criticality Safety Program* (Chapter 6)
   - Radiation Protection* (Chapter 7)
   - Hazardous Material Protection* (Chapter 8)
   - Radioactive and Hazardous Waste Management* (Chapter 9)
   - Initial Testing, In-Service Surveillance, and Maintenance (Chapter 10)
   - Operational Safety* (Conduct of Operations/Fire Protection) (Chapter 11)
   - Procedures and Training (Chapter 12)
   - Quality Assurance* (Chapter 14)
   - Emergency Preparedness Program* (Chapter 15)
   - Management, Organization and Institutional Safety Provisions (Chapter 17)

   Note: Program key element "c," listed below, only applies to those SMPs identified above by an asterisk.

b. Project Management SHALL ensure the overall safety function of an SMP (identified above) is maintained through implementation of all applicable program key attributes identified in HNF-11724, as modified in Chapter 5.0 of this DSA. They will also ensure facility-level SMP implementation assessments are performed on those SMPs identified in key element "a."

c. For those SMPs identified above by an asterisk (*), the resulting data will be provided to the appropriate program manager for tracking and trending, and corrective action management required by PRC-PRO-QA-052, *Issues Management*, or successor document.

C.5.1.3 Responsibility

Facility Management is responsible to ensure that the applicable commitments of the SMPs are implemented and that the continuous improvement commitment of the Integrated Safety Management System is maintained.

C.5.1.4 Recovery

See Section C.1.8.

C.5.1.5 Basis

These SMPs provide significant contributions to worker safety and are an integral part of safe S&M operations at the REDOX Facility.

C.5.2 Waste Inventory Control (SAC)

C.5.2.1 Applicability

This SAC applies to the staged transuranic (TRU) waste that may be generated as removed TRU contaminated equipment. This SAC is applicable only to externally staged TRU waste at the REDOX Facility, and prohibits the addition of outside radiological material. The limit of 6.23 DE-Ci, as shown in Table C-2, applies to TRU waste and TRU contaminated equipment removed from REDOX buildings. The TSR remains applicable until the facility is recategorized as less than Hazard Category 3.

Note: This TSR is not applicable to Environmental Restoration Disposal Facility (ERDF) roll-on/roll-off (RO/RO) waste boxes associated with general building rubble and components of ancillary facilities, that are low-level waste (less than Hazard Category 3 threshold quantities).

C.5.2.2 Critical Safety Function

The Waste Inventory Control is the initial underlying assumption for the accident analysis performed in Section 3.4.6 in this DSA. The Waste Inventory Control provides external TRU waste inventory limits in DE-Ci for the REDOX Facility. The material-at-risk (MAR) limit protects accident assumptions and ensures that the consequences determined in the accident scenario are not invalidated thereby placing the facility in unanalyzed space.

C.5.2.3 Requirements

a. The total staged TRU waste and TRU contaminated equipment removed from REDOX buildings is limited to less than 6.23 DE-Ci.

b. TRU waste arrays (staging areas) must be separated by at least 10 m (33 ft).

C.5.2.4 Responsibility

Facility Management is responsible for ensuring that the radiological inventories are managed as required in Section C.5.2.3. Inventory control records SHALL be maintained according to quality requirements that are contractually applicable. Anticipated TRU waste will require characterization and/or nondestructive assay prior to removal, staging, and disposition.

C.5.2.5 SAC C.5.2 ACTION Statements

Noncompliance with a requirement of this Directive Action TSR SAC is a TSR VIOLATION. Discovery of a non-compliant condition based on new characterization information (e.g., revised isotopic or hazardous material inventories, physical waste characteristics, fissile content, and radionuclide inventories) SHALL not constitute a requirement not met if the applicable containers are redesigned and managed in accordance with applicable TSR SAC requirements within 7 calendar days of the discovery of the new characterization information. If the impacted waste is not managed in accordance with applicable TSR SAC elements within 7 calendar days, the TSR SAC elements will be declared "not met" and the applicable notifications and recovery actions will be pursued.

The following ACTIONS are required for the SAC C.5.2 requirement not met:

SAC REQUIREMENT NOT MET ACTIONS		
CONDITION	**REQUIRED ACTION**	**COMPLETION TIME**
A. The SAC requirement is not met.	A.1.1 Terminate affected ACTIVITY(ies) IMMEDIATELY except as necessary to achieve a safe configuration. **AND** A.1.2 Take actions of Section C.1.8. **AND**	IMMEDIATELY
	A.2.1 Initiate ACTIVITIES, including waste operations, as required to restore the SAC requirement. **OR** A.2.2 Notify the RL Facility Representative **AND**	10 work days
	A.3.1 Develop a facility-approved recovery plan and initiate actions of the recovery plan. RL expects that Facility Management will work diligently to complete the recovery plan and restore the SAC element.	Within 10 work days above

Affected ACTIVITY(ies) may be resumed at any time when the relevant SAC requirement has been restored.

C.5.2.6 Basis

The Waste Staging Fire accident analysis within the DSA (Section 3.4.6) assumes a radiological inventory and configuration that define the analyzed dose consequences for externally staged

TRU waste and TRU contaminated equipment external to REDOX buildings. This SAC ensures that the applicable material-at-risk (MAR) inventory assumption of 6.23 DE-Ci derived from the inventory in the DSA is maintained. Table C-2 below converts the accident analysis MAR assumptions to DE-Ci, which simplifies the analysis for maintaining radiological inventories..

Table C-2. REDOX Isotope Mix

Isotope	Packaged Waste (g)	Packaged Waste (Ci)	DE-Ci
^{90}Sr	2.73E-01	3.72E+01	1.79E-02
^{239}Pu	1.00E+02	6.21E+00	6.21E+00
		Total	6.23E+00

This TSR does not limit the accumulation of low-level waste (LLW)/mixed low-level waste (MLLW). Per CP-51329, *Evaluation of TSR Compliance for the 224-T Waste Storage Area and all Surveillance and Maintenance Satellite Accumulation Waste Areas*, an excessive amount of LLW/MLLW (as characterized in the waste profile WP-PRCIFSM001, *Waste Stream Profile: Central Plateau Surveillance and Maintenance Facilities*) is necessary to exceed the MAR limits established in the CP S&M safety bases (ranging from 6.3-41.8 DE-Ci). For perspective, two ERDF roll-off waste boxes have a total volume of 44.80 m^3 (1582 ft^3) with a maximum gross container weight of 100,000 lbs. which equates to approximately 0.3 DE-Ci based on the general low-level waste profile described in WP-PRCIFSM001. Administratively per waste packaging procedures, ERDF roll-off waste boxes are limited to 40,000 lbs., so one ERDF box is approximately 0.15 DE-Ci. Therefore, in order to reach the facility specific MAR limits, 41 ERDF roll-off waste boxes filled with LLW/MLLW would need to be staged outside of REDOX.

C.5.3 Flammable Atmosphere Control (SAC)

C.5.3.1 Applicability

This Directive Action SPECIFIC ADMINISTRATIVE CONTROL establishes requirements for venting potential flammable gas containing equipment and systems within the REDOX facility. Flammable Atmosphere Control is credited in DSA accident analyses with minimizing the frequency of a flammable gas deflagration within equipment.

C.5.3.2 Critical Safety Function

The Flammable Atmosphere Control ensures that systems with a potentially flammable atmosphere will be evaluated, vented, and monitored. This control is designated as a SS TSR (SAC) because its function is credited to prevent the FW from sustaining serious injury caused by an internal deflagration, or from flying objects (missiles) created by the deflagration. This operational event is described in the accident analysis, Section 3.4.7.

C.5.3.3 Requirements

The following control set SHALL be implemented when performing intrusive activities with potential flammable gas containing equipment and systems:

Cutting controls for flammable gas environments SHALL be implemented. These controls include the following provisions:

- Evaluation of the system (piping, tank, vessels and connected systems) to determine the potential for flammable gas generation. The evaluation and resultant hazard control SHALL be documented and maintained in the applicable technical work document.
- Purging, flow due to application of negative pressure drop, or diffusion of systems that have the potential for flammable gas generation.
- Performance of confirmative flammable gas monitoring to ensure flammable gas concentration is less than 10 percent of the Lower Explosive Limit (LEL) prior to use of mechanical cutting devices that produce an ignition source.

Exception to flammable gas monitoring:

- If the system is not vented and flammable gas monitoring cannot be performed, then a process for cutting/removing metallic material, piping, or fixtures that limits the imparted energy during the process and reduces the probability of initiating a deflagration or detonation shall be developed for the specific application. More information, including an example, can be found in CHPRC-1502750.

C.5.3.4 Responsibility

Facility Management is responsible for ensuring that intrusive operations SHALL be managed as required in the above requirements statement, Section C.5.3.3.

C.5.3.5 SAC C.5.3 ACTION Statements

Noncompliance with a requirement of this Directive Action TSR SAC is a TSR VIOLATION. Discovery of a non-compliant condition based on new characterization information (e.g., revised hazardous material inventories, physical waste characteristics, unanticipated hazardous materials detected) SHALL not constitute a requirement not met if work is immediately stopped except as necessary to achieve a safe configuration, and the applicable piping or equipment is managed in accordance with applicable TSR SAC requirements within 7 calendar days of the discovery of the new characterization information. If the piping or equipment is not managed in accordance with applicable TSR SAC elements within 7 calendar days, the TSR SAC elements will be declared "not met" and the applicable notifications and recovery actions will be pursued.

The following ACTIONS are required for the SAC C.3.5 requirement not met:

SAC REQUIREMENT NOT MET ACTIONS		
CONDITION	**REQUIRED ACTION**	**COMPLETION TIME**
A. The SAC requirement is not met.	A.1.1 Terminate affected ACTIVITY(ies) IMMEDIATELY except as necessary to achieve a safe configuration. **AND** A.1.2 Take actions of Section C.1.8. **AND**	IMMEDIATELY
	A.2.1 Initiate ACTIVITIES, including waste operations, as required to restore the SAC requirement. **OR** A.2.2 Notify the RL Facility Representative **AND**	10 work days
	A.3.1 Develop a facility-approved recovery plan and initiate actions of the recovery plan. RL expects that Facility Management will work diligently to complete the recovery plan and restore the SAC element.	Within 10 work days above

Affected ACTIVITY(ies) may be resumed at any time when the relevant SAC requirement has been restored.

C.5.3.6 Basis

DSA Scenario 3.4.7, Internal Equipment Deflagrations, considers the potential for a deflagration within a pipe, ductwork, or similar confining equipment being removed for risk reduction purposes. This scenario is initiated from the ignition of flammable gas such as from hydrogen generation, or vapors from residual process equipment. This scenario relies on the requirements of the Flammable Atmosphere Control SAC to minimize the frequency of internally generated flammable gas or vapor explosions within equipment. This control has been established to minimize the potential for internal equipment deflagrations generating projectiles that could cause serious injury/death to the FW.

C.6 Design Features

There are no DESIGN FEATURES identified at the REDOX Facility. The REDOX Building structure is not identified as SC or SS and no credit is taken for reduction of accident consequences in the accident analyses performed in Section 3.4. However, the REDOX Building structure is identified as providing defense-in-depth and all changes or modifications to the REDOX Facility are subjected to the USQ process and not subject to change by operations personnel.

C.7 References

10 CFR 830, "Nuclear Safety Management," *Code of Federal Regulations*, as amended.

CHPRC-1502750, *The Crimp/Cut (or Shearing) Method of Size Reducing Pipe*, (memorandum to T. C. Oten from R. M. Marusich, June 30), CH2M Hill Plateau Remediation Company, Richland, Washington.

CP-51329 Rev. 2, *Evaluation of TSR Compliance for the 224-T Waste Storage Area and all Surveillance and Maintenance Satellite Accumulation Waste Areas*

DOE-STD-1027-92, 1997, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, Change Notice No. 1, U.S. Department of Energy, Washington, D.C.

HNF-7098, *Criticality Safety Program*, as amended, Fluor Hanford, Inc., Richland, Washington.

HNF-11724, *CH2M HILL Plateau Remediation Company Safety Management Programs*, CH2M HILL Plateau Remediation Company, Richland, Washington, as amended.

PRC-PRO-QA-052, *Issues Management*, CH2M HILL Plateau Remediation Company, as amended, Richland, Washington.

WP-PRCIFSM001, 2012, *Waste Stream Profile: Central Plateau Surveillance and Maintenance Facilities)*, Rev. 0, Washington Closure Hanford, Richland, Washington.

Appendix D

RADIDOSE Output Sheets

Appendix D

RADIDOSE Version 3.0 (5-18-2005)

Input Parameter	User Input	Default	Description (based on user input)
Facility/Material (1-14):	13		User-defined mixture ("InSource" page)
Form of Material (1-10):		7	Pu Oxide and Other Powders
Accident Type (1-6):	2		External Impact
Quantity at Risk (MAR):	1.15E+04		ci
Damage Ratio:		1	
Airborne Release Fraction:	1.00E-03		ARF
Respirable Fraction:	1.00E-01		RF
Leak Path Factor:		1	LPF (applies to particulate only)
HEPA Filter Factor:	1		DF = 1 (applies to particulate only)
Collocated Worker Dose Factor:		3	ICRP 68, 5 μm AMAD
Onsite & Offsite Public Dose Factor:		7	ICRP 72 for Adult
Material Solubility Class:		2	compounds are generally soluble
Hanford Processing Area (1-4):		2	200 Area
Distance or X/Q for Collocated Worker:	0.0035	at 369 m	s/m3
Distance or X/Q for Onsite Public:	4300		meters
Distance or X/Q for Offsite Public:	12580		meters
Emission Source Type (1-4):		1	Point source at ground level
Release Duration (0 to 8760 h):		0.5	hours

Description of Accident Scenario: Edit using function key F2. Carriage returns are not allowed.

Section 3.4.1 Seismic Event - MAR assumed to be 100% of 202-S and ancillary buildings. X/Q = 3.5E-3

Dose Results for the Postulated Accident:

Material source amounts are listed on the "UnitDF" page.

User-defined mixture ("InSource" page)				
		Pu Oxide and Other Powders		
Point Source At Ground Level				200 Area
Total Respirable Release:	1.15E+00 ci			
Dose Factors:	ICRP 68, 5μm	ICRP 72 for Adult		Release
	Collocated	Onsite	Offsite	Duration
Receptor:	Worker	Public	Public	0.5 h
Distance:	369 m	4,300 m	12,580 m	
X/Q:	3.50E-03	7.55E-05	1.88E-05	s/m3
Breathing Rate:	3.35E-04	3.29E-04	3.29E-04	m3/s
Unit DCF:	1.70E+07	2.66E+07	2.66E+07	rem/ci
Total Dose:	**2.30E+01**	**7.59E-01**	**1.89E-01**	**rem**
Consequence:	Low	na	Low	

User-Defined Source Material 2 nuclides

Note: Full printout is 36 pages. Typical cases only need the first few pages.

	User Input	Default	
MAR unit:	ci		
Enter activities or masses?	1		enter activity per ci

Nuclide	Curies per ci	Specific Activity, Ci/g	Grams per ci	FGR Index	2.310E+00 Fraction
Sr-90	8.57E-01	1.37E+02	6.28E-03	164	2.72E-03
Pu-239	1.43E-01	6.21E-02	2.30E+00	776	9.97E-01

RADIDOSE Version 3.0 (5-18-2005)

Input Parameter	User Input	Default	Description (based on user input)
Facility/Material (1-14):	13		User-defined mixture ("InSource" page)
Form of Material (1-10):	3		Non-combustible Contaminated Solids
Accident Type (1-6):	1		Fire
Quantity at Risk (MAR):	1.43E+00		ci
Damage Ratio:		1	
Airborne Release Fraction:	6.00E-03		ARF
Respirable Fraction:	1.00E-02		RF
Leak Path Factor:		1	LPF (applies to particulate only)
HEPA Filter Factor:	1		DF = 1 (applies to particulate only)
Collocated Worker Dose Factor:		3	ICRP 68, 5 μm AMAD
Onsite & Offsite Public Dose Factor:		7	ICRP 72 for Adult
Material Solubility Class:	2		compounds are generally soluble
Hanford Processing Area (1-4):		2	200 Area
Distance or X/Q for Collocated Worker:	0.0035	at 369 m	s/m3
Distance or X/Q for Onsite Public:	4300		meters
Distance or X/Q for Offsite Public:	12580		meters
Emission Source Type (1-4):	1		Point source at ground level
Release Duration (0 to 8760 h):		0.5	hours

Description of Accident Scenario: Edit using function key F2. Carriage returns are not allowed.

Section 3.4.2 PR Cage Fire - Segment 1 - Non-combustible equipment surfaces - MAR assigned to con-combustible equipment surfaces is assumed to be half of the residual contamination in the sump. X/Q = 3.5E-3

Dose Results for the Postulated Accident:

Material source amounts are listed on the "UnitDF" page.

User-defined mixture ("InSource" page)				
	Non-combustible Contaminated Solids			
Point Source At Ground Level				**200 Area**
Total Respirable Release:	8.58E-05	ci		
Dose Factors:	ICRP 68, 5μm	ICRP 72 for Adult		Release
	Collocated	**Onsite**	**Offsite**	Duration
Receptor:	**Worker**	**Public**	**Public**	0.5 h
Distance:	369 m	4,300 m	12,580 m	
X/Q:	3.50E-03	7.55E-05	1.88E-05	s/m3
Breathing Rate:	3.35E-04	3.29E-04	3.29E-04	m3/s
Unit DCF:	1.53E+07	2.38E+07	2.38E+07	rem/ci
Total Dose:	**1.53E-03**	**5.07E-05**	**1.26E-05**	**rem**
Consequence:	Low	na	Low	

User-Defined Source Material

2 nuclides

Note: Full printout is 36 pages. Typical cases only need the first few pages.

	User Input	Default	
MAR unit:	ci		
Enter activities or masses?	1		enter activity per ci

Nuclide	Curies per ci	Specific Activity, Ci/g	Grams per ci	FGR Index	2.069E+00 Fraction
Sr-90	8.72E-01	1.37E+02	6.39E-03	164	3.09E-03
Pu-239	1.28E-01	6.21E-02	2.06E+00	776	9.97E-01

RADIDOSE Version 3.0 (5-18-2005)

Input Parameter	User Input	Default	Description (based on user input)
Facility/Material (1-14):	13		User-defined mixture ("InSource" page)
Form of Material (1-10):	4		Uncontained Contaminated Organic Solids
Accident Type (1-6):	1		Fire
Quantity at Risk (MAR):	1.43E+00		ci
Damage Ratio:		1	
Airborne Release Fraction:	5.00E-02		ARF
Respirable Fraction:	1.00E+00		RF
Leak Path Factor:		1	LPF (applies to particulate only)
HEPA Filter Factor:	1		DF = 1 (applies to particulate only)
Collocated Worker Dose Factor:		3	ICRP 68, 5 μm AMAD
Onsite & Offsite Public Dose Factor:		7	ICRP 72 for Adult
Material Solubility Class:	2		compounds are generally soluble
Hanford Processing Area (1-4):		2	200 Area
Distance or X/Q for Collocated Worker:	0.0035	at 369 m	s/m3
Distance or X/Q for Onsite Public:	4300		meters
Distance or X/Q for Offsite Public:	12580		meters
Emission Source Type (1-4):	1		Point source at ground level
Release Duration (0 to 8760 h):		0.5	hours

Description of Accident Scenario: Edit using function key F2. Carriage returns are not allowed.

Section 3.4.2 PR Cage Fire - Segment 2 -Polymethylmethacrylate (PMMA) surfaces - MAR assigned to PMMA surfaces is assumed to be half of the residual contamination in the sump. X/Q = 3.5E-3

Dose Results for the Postulated Accident:

Material source amounts are listed on the "UnitDF" page.

User-defined mixture ("InSource" page)				
	Uncontained Contaminated Organic Solids			
Point Source At Ground Level				200 Area
Total Respirable Release:	7.15E-02 ci			
Dose Factors:	ICRP 68, 5μm	ICRP 72 for Adult		Release Duration 0.5 h
Receptor:	Collocated Worker	Onsite Public	Offsite Public	
Distance:	369 m	4,300 m	12,580 m	
X/Q:	3.50E-03	7.55E-05	1.88E-05	s/m3
Breathing Rate:	3.35E-04	3.29E-04	3.29E-04	m3/s
Unit DCF:	1.53E+07	2.38E+07	2.38E+07	rem/ci
Total Dose:	**1.28E+00**	**4.23E-02**	**1.05E-02**	**rem**
Consequence:	Low	na	Low	

User-Defined Source Material

2 nuclides

Note: Full printout is 36 pages. Typical cases only need the first few pages.

	User Input	Default	
MAR unit:	ci		
Enter activities or masses?	1		enter activity per ci

Nuclide	Curies per ci	Specific Activity, Ci/g	Grams per ci	FGR Index	2.069E+00 Fraction
Sr-90	8.72E-01	1.37E+02	6.39E-03	164	3.09E-03
Pu-239	1.28E-01	6.21E-02	2.06E+00	776	9.97E-01

RADIDOSE Version 3.0 (5-18-2005)

Input Parameter	User Input	Default	Description (based on user input)
Facility/Material (1-14):	13		User-defined mixture ("InSource" page)
Form of Material (1-10):	3		Non-combustible Contaminated Solids
Accident Type (1-6):	1		Fire
Quantity at Risk (MAR):	3.15E+02		ci
Damage Ratio:		1	
Airborne Release Fraction:	6.00E-03		ARF
Respirable Fraction:	1.00E-02		RF
Leak Path Factor:		1	LPF (applies to particulate only)
HEPA Filter Factor:	1		DF = 1 (applies to particulate only)
Collocated Worker Dose Factor:		3	ICRP 68, 5 μm AMAD
Onsite & Offsite Public Dose Factor:		7	ICRP 72 for Adult
Material Solubility Class:	2		compounds are generally soluble
Hanford Processing Area (1-4):		2	200 Area
Distance or X/Q for Collocated Worker:	0.0035	at 369 m	s/m3
Distance or X/Q for Onsite Public:	4300		meters
Distance or X/Q for Offsite Public:	12580		meters
Emission Source Type (1-4):	1		Point source at ground level
Release Duration (0 to 8760 h):		0.5	hours

Description of Accident Scenario: Edit using function key F2. Carriage returns are not allowed.

Section 3.4.3 Silo Fire - Assumptions - Per Table 3-1, 10% of the 202-S inventory (excluding the North Sample Gallery) is surface contamination in the Silo and Column Laydown Trench. 30% of this Silo inventory is assumed to be availalbe for release on non-combustible equipment surfaces. X/Q = 3.5E-3

Dose Results for the Postulated Accident:

Material source amounts are listed on the "UnitDF" page.

User-defined mixture ("InSource" page)				
Non-combustible Contaminated Solids				
Point Source At Ground Level				200 Area
Total Respirable Release:	1.89E-02	ci		
Dose Factors:	ICRP 68, 5μm	ICRP 72 for Adult		Release
Receptor:	Collocated Worker	Onsite Public	Offsite Public	Duration 0.5 h
Distance:	369 m	4,300 m	12,580 m	
X/Q:	3.50E-03	7.55E-05	1.88E-05	s/m3
Breathing Rate:	3.35E-04	3.29E-04	3.29E-04	m3/s
Unit DCF:	1.70E+07	2.66E+07	2.66E+07	rem/ci
Total Dose:	**3.77E-01**	**1.25E-02**	**3.10E-03**	**rem**
Consequence:	Low	na	Low	

User-Defined Source Material

2 nuclides

Note: Full printout is 36 pages. Typical cases only need the first few pages.

	User Input	Default	
MAR unit:	ci		
Enter activities or masses?	1		enter activity per ci

Nuclide	Curies per ci	Specific Activity, Ci/g	Grams per ci	FGR Index	2.310E+00 Fraction
Sr-90	8.57E-01	1.37E+02	6.28E-03	164	2.72E-03
Pu-239	1.43E-01	6.21E-02	2.30E+00	776	9.97E-01

RADIDOSE Version 3.0 (5-18-2005)

Input Parameter	User Input	Default	Description (based on user input)
Facility/Material (1-14):	13		User-defined mixture ("InSource" page)
Form of Material (1-10):		7	Pu Oxide and Other Powders
Accident Type (1-6):	2		External Impact
Quantity at Risk (MAR):	3.50E+03		ci
Damage Ratio:		1	
Airborne Release Fraction:	1.00E-03		ARF
Respirable Fraction:	1.00E-01		RF
Leak Path Factor:		1	LPF (applies to particulate only)
HEPA Filter Factor:	1		DF = 1 (applies to particulate only)
Collocated Worker Dose Factor:		3	ICRP 68, 5 µm AMAD
Onsite & Offsite Public Dose Factor:		7	ICRP 72 for Adult
Material Solubility Class:	2		compounds are generally soluble
Hanford Processing Area (1-4):		2	200 Area
Distance or X/Q for Collocated Worker:	0.0035	at 369 m	s/m3
Distance or X/Q for Onsite Public:	4300		meters
Distance or X/Q for Offsite Public:	12580		meters
Emission Source Type (1-4):		1	Point source at ground level
Release Duration (0 to 8760 h):		0.5	hours

Description of Accident Scenario: Edit using function key F2. Carriage returns are not allowed.

Section 3.4.4 Canyon Load Drop - MAR assumed to be 33% of the canyon inventory. X/Q = 3.5E-3
Section 3.4.8 Aircraft Impact Event (Mechanical)

Dose Results for the Postulated Accident:

Material source amounts are listed on the "UnitDF" page.

User-defined mixture ("InSource" page)				
	Pu Oxide and Other Powders			
Point Source At Ground Level				**200 Area**
Total Respirable Release:	3.50E-01	ci		
Dose Factors:	ICRP 68, 5µm	ICRP 72 for Adult		Release
Receptor:	**Collocated Worker**	**Onsite Public**	**Offsite Public**	Duration 0.5 h
Distance:	369 m	4,300 m	12,580 m	
X/Q:	3.50E-03	7.55E-05	1.88E-05	s/m3
Breathing Rate:	3.35E-04	3.29E-04	3.29E-04	m3/s
Unit DCF:	1.70E+07	2.66E+07	2.66E+07	rem/ci
Total Dose:	**6.99E+00**	**2.31E-01**	**5.74E-02**	**rem**
Consequence:	Low	na	Low	

User-Defined Source Material

2 nuclides

Note: Full printout is 36 pages. Typical cases need only the first few pages.

	User Input	Default	
MAR unit:	ci		
Enter activities or masses?	1		enter activity per ci

Nuclide	Curies per ci	Specific Activity, Ci/g	Grams per ci	FGR Index	2.310E+00 Fraction
Sr-90	8.57E-01	1.37E+02	6.28E-03	164	2.72E-03
Pu-239	1.43E-01	6.21E-02	2.30E+00	776	9.97E-01

RADIDOSE Version 3.0 (5-18-2005)

Input Parameter	User Input	Default	Description (based on user input)
Facility/Material (1-14):	13		User-defined mixture ("InSource" page)
Form of Material (1-10):	3		Non-combustible Contaminated Solids
Accident Type (1-6):	2		External Impact
Quantity at Risk (MAR):	8.34E+03		ci
Damage Ratio:		1	
Airborne Release Fraction:	1.20E-05		ARF
Respirable Fraction:	2.50E-01		RF
Leak Path Factor:		1	LPF (applies to particulate only)
HEPA Filter Factor:	1		DF = 1 (applies to particulate only)
Collocated Worker Dose Factor:		3	ICRP 68, 5 μm AMAD
Onsite & Offsite Public Dose Factor:		7	ICRP 72 for Adult
Material Solubility Class:		2	compounds are generally soluble
Hanford Processing Area (1-4):		2	200 Area
Distance or X/Q for Collocated Worker:		100	meters
Distance or X/Q for Onsite Public:	4300		meters
Distance or X/Q for Offsite Public:	12580		meters
Emission Source Type (1-4):		1	Point source at ground level
Release Duration (0 to 8760 h):		0.5	hours

Description of Accident Scenario: Edit using function key F2. Carriage returns are not allowed.

Section 3.4.1 Seismic Event
Section 3.4.5 Ventilation Sand Filter Load Drop
MAR assumed to be 100% of the sand filter inventory. DR= 1. ARF*RF = 1.2E-5*2.5E-1 as per PRC-STD-NS-8739

Dose Results for the Postulated Accident:

Material source amounts are listed on the "UnitDF" page.

User-defined mixture ("InSource" page)				
Non-combustible Contaminated Solids				
Point Source At Ground Level				200 Area
Total Respirable Release:	2.50E-02 ci			
Dose Factors:	ICRP 68, 5μm	ICRP 72 for Adult		Release
Receptor:	Collocated Worker	Onsite Public	Offsite Public	Duration 0.5 h
Distance:	100 m	4,300 m	12,580 m	
X/Q:	3.28E-02	7.55E-05	1.88E-05	s/m3
Breathing Rate:	3.35E-04	3.29E-04	3.29E-04	m3/s
Unit DCF:	4.93E+06	7.67E+06	7.67E+06	rem/ci
Total Dose:	**1.36E+00**	**4.77E-03**	**1.18E-03**	**rem**
Consequence:	Low	na	Low	

User-Defined Source Material

2 nuclides

Note: Full printout is 36 pages. Typical cases only need the first few pages.

	User Input	Default	
MAR unit:	ci		
Enter activities or masses?	1		enter activity per ci

Nuclide	Curies per ci	Specific Activity, Ci/g	Grams per ci	FGR Index	6.639E-01 Fraction
Sr-90	9.59E-01	1.37E+02	7.02E-03	164	1.06E-02
Pu-239	4.08E-02	6.21E-02	6.57E-01	776	9.89E-01

RADIDOSE Version 3.0 (5-18-2005)

Input Parameter	User Input	Default	Description (based on user input)
Facility/Material (1-14):	13		User-defined mixture ("InSource" page)
Form of Material (1-10):	1		Packaged Waste (bags, drums, boxes)
Accident Type (1-6):	1		Fire
Quantity at Risk (MAR):	4.34E+01		ci
Damage Ratio:		1	
Airborne Release Fraction:	0.0005		ARF
Respirable Fraction:	1		RF
Leak Path Factor:		1	LPF (applies to particulate only)
HEPA Filter Factor:	1		DF = 1 (applies to particulate only)
Collocated Worker Dose Factor:		3	ICRP 68, 5 μm AMAD
Onsite & Offsite Public Dose Factor:		7	ICRP 72 for Adult
Material Solubility Class:	2		compounds are generally soluble
Hanford Processing Area (1-4):		2	200 Area
Distance or X/Q for Collocated Worker:		100	meters
Distance or X/Q for Onsite Public:	4300		meters
Distance or X/Q for Offsite Public:	12580		meters
Emission Source Type (1-4):	1		Point source at ground level
Release Duration (0 to 8760 h):		0.5	hours

Description of Accident Scenario: Edit using function key F2. Carriage returns are not allowed.

Section 3.4.6. Staged Waste Fire - Assumptions: Packaged waste container inventory contains 100g Pu-239 and a proportional amount of Sr-90. Conservatively assumed point source release.

Dose Results for the Postulated Accident:

Material source amounts are listed on the "UnitDF" page.

User-defined mixture ("InSource" page)				
Packaged Waste (bags, drums, boxes)				
Point Source At Ground Level				200 Area
Total Respirable Release:	2.17E-02	ci		
Dose Factors:	ICRP 68, 5μm	ICRP 72 for Adult		Release Duration 0.5 h
Receptor:	Collocated Worker	Onsite Public	Offsite Public	
Distance:	100 m	4,300 m	12,580 m	
X/Q:	3.28E-02	7.55E-05	1.88E-05	s/m3
Breathing Rate:	3.35E-04	3.29E-04	3.29E-04	m3/s
Unit DCF:	1.70E+07	2.66E+07	2.66E+07	rem/ci
Total Dose:	**4.06E+00**	**1.43E-02**	**3.56E-03**	**rem**
Consequence:	Low	na	Low	

User-Defined Source Material

2 nuclides

Note: Full printout is 36 pages. Typical cases only need the first few pages.

	User Input	Default	
MAR unit:	ci		
Enter activities or masses?	1		enter activity per ci

Nuclide	Curies per ci	Specific Activity, Ci/g	Grams per ci	FGR Index	2.310E+00 Fraction
Sr-90	8.57E-01	1.37E+02	6.28E-03	164	2.72E-03
Pu-239	1.43E-01	6.21E-02	2.30E+00	776	9.97E-01

RADIDOSE Version 3.0 (5-18-2005)

Input Parameter	User Input	Default	Description (based on user input)
Facility/Material (1-14):	1		Plutonium Finishing Plant: < 10% Pu-240
Form of Material (1-10):		7	Pu Oxide and Other Powders
Accident Type (1-6):	4		Internal Explosion or Overpressure
Quantity at Risk (MAR):	6.00E+01		gram
Damage Ratio:		1	
Airborne Release Fraction:	2.00E-04		ARF
Respirable Fraction:	1.00E+00		RF
Leak Path Factor:		1	LPF (applies to particulate only)
HEPA Filter Factor:	1		DF = 1 (applies to particulate only)
Collocated Worker Dose Factor:		3	ICRP 68, 5 μm AMAD
Onsite & Offsite Public Dose Factor:		7	ICRP 72 for Adult
Material Solubility Class:	2		compounds are generally soluble
Hanford Processing Area (1-4):		2	200 Area
Distance or X/Q for Collocated Worker:	0.0035	at 369 m	s/m3
Distance or X/Q for Onsite Public:	4300		meters
Distance or X/Q for Offsite Public:	12580		meters
Emission Source Type (1-4):	1		Point source at ground level
Release Duration (0 to 8760 h):		0.5	hours

Description of Accident Scenario: Edit using function key F2. Carriage returns are not allowed.

Section 3.4.7 Internal Equiptment Deflagration - Inventory contains 60g Pu-239 with < 10% Pu-240. ARF*RF value is set to 2.00E-04. X/Q = 3.5E-3

Dose Results for the Postulated Accident:

Material source amounts are listed on the "UnitDF" page.

Plutonium Finishing Plant: < 10% Pu-240 – New composition (2004)				
Pu Oxide and Other Powders				
Point Source At Ground Level				**200 Area**
Total Respirable Release:	1.20E-02	gram		
Dose Factors:	ICRP 68, 5μm	ICRP 72 for Adult		Release
Receptor:	**Collocated Worker**	**Onsite Public**	**Offsite Public**	Duration 0.5 h
Distance:	369 m	4,300 m	12,580 m	
X/Q:	3.50E-03	7.55E-05	1.88E-05	s/m3
Breathing Rate:	3.35E-04	3.29E-04	3.29E-04	m3/s
Unit DCF:	9.65E+06	1.51E+07	1.51E+07	rem/gram
Total Dose:	**1.36E-01**	**4.49E-03**	**1.12E-03**	rem
Consequence:	Low	na	Low	

RADIDOSE Version 3.0 (5-18-2005)

Input Parameter	User Input	Default	Description (based on user input)
Facility/Material (1-14):	13		User-defined mixture ("InSource" page)
Form of Material (1-10):	3		Non-combustible Contaminated Solids
Accident Type (1-6):	1		Fire
Quantity at Risk (MAR):	3.15E+03		ci
Damage Ratio:		1	
Airborne Release Fraction:	6.00E-03		ARF
Respirable Fraction:	1.00E-02		RF
Leak Path Factor:		1	LPF (applies to particulate only)
HEPA Filter Factor:	1		DF = 1 (applies to particulate only)
Collocated Worker Dose Factor:		3	ICRP 68, 5 µm AMAD
Onsite & Offsite Public Dose Factor:		7	ICRP 72 for Adult
Material Solubility Class:	2		compounds are generally soluble
Hanford Processing Area (1-4):		2	200 Area
Distance or X/Q for Collocated Worker:	0.0035	at 369 m	s/m3
Distance or X/Q for Onsite Public:	4300		meters
Distance or X/Q for Offsite Public:	12580		meters
Emission Source Type (1-4):	1		Point source at ground level
Release Duration (0 to 8760 h):		0.5	hours

Description of Accident Scenario: Edit using function key F2. Carriage returns are not allowed.

Section 3.4.8 Aircraft Fire Part #1 - Assumptions - The MAR is assumed to be 90% of "1/3" of the total 202-S Canyon inventory and is available for release as Non-combustible Contaminated Solids.
ARF*RF = 6.0E-03 and 1.0E-02
X/Q = 3.5E-3

Dose Results for the Postulated Accident:

Material source amounts are listed on the "UnitDF" page.

User-defined mixture ("InSource" page)				
	Non-combustible Contaminated Solids			
Point Source At Ground Level				**200 Area**
Total Respirable Release:	1.89E-01 ci			
Dose Factors:	ICRP 68, 5µm	ICRP 72 for Adult		Release Duration 0.5 h
Receptor:	**Collocated Worker**	**Onsite Public**	**Offsite Public**	
Distance:	369 m	4,300 m	12,580 m	
X/Q:	3.50E-03	7.55E-05	1.88E-05	s/m3
Breathing Rate:	3.35E-04	3.29E-04	3.29E-04	m3/s
Unit DCF:	1.70E+07	2.66E+07	2.66E+07	rem/ci
Total Dose:	**3.77E+00**	**1.25E-01**	**3.10E-02**	**rem**
Consequence:	Low	na	Low	

User-Defined Source Material 2 nuclides

Note: Full printout is 36 pages. Typical cases only need the first few pages.

		User Input	Default		
	MAR unit:	ci			
Enter activities or masses?		1		enter activity per ci	
Nuclide	**Curies per ci**	**Specific Activity, Ci/g**	**Grams per ci**	**FGR Index**	**2.310E+00 Fraction**
Sr-90	8.57E-01	1.37E+02	6.28E-03	164	2.72E-03
Pu-239	1.43E-01	6.21E-02	2.30E+00	776	9.97E-01

RADIDOSE Version 3.0 (5-18-2005)

Input Parameter	User Input	Default	Description (based on user input)
Facility/Material (1-14):	13		User-defined mixture ("InSource" page)
Form of Material (1-10):		7	Pu Oxide and Other Powders
Accident Type (1-6):	1		Fire
Quantity at Risk (MAR):	3.50E+02		ci
Damage Ratio:		1	
Airborne Release Fraction:	6.00E-03		ARF
Respirable Fraction:	1.00E-01		RF
Leak Path Factor:		1	LPF (applies to particulate only)
HEPA Filter Factor:	1		DF = 1 (applies to particulate only)
Collocated Worker Dose Factor:		3	ICRP 68, 5 μm AMAD
Onsite & Offsite Public Dose Factor:		7	ICRP 72 for Adult
Material Solubility Class:	2		compounds are generally soluble
Hanford Processing Area (1-4):		2	200 Area
Distance or X/Q for Collocated Worker:	0.0035	at 369 m	s/m3
Distance or X/Q for Onsite Public:	4300		meters
Distance or X/Q for Offsite Public:	12580		meters
Emission Source Type (1-4):	1		Point source at ground level
Release Duration (0 to 8760 h):		0.5	hours

Description of Accident Scenario: Edit using function key F2. Carriage returns are not allowed.

Section 3.4.8 Aircraft Fire Part #2 - Assumptions - The MAR is assumed to be 10% of "1/3" of the total 202-S Canyon inventory and is available for release as very combustible Pu Oxide and other Powders. X/Q = 3.5E-3

Dose Results for the Postulated Accident:

Material source amounts are listed on the "UnitDF" page.

User-defined mixture ("InSource" page)				
Pu Oxide and Other Powders				
Point Source At Ground Level				**200 Area**
Total Respirable Release:	2.10E-01	ci		
Dose Factors:	ICRP 68, 5μm	ICRP 72 for Adult		Release Duration 0.5 h
Receptor:	**Collocated Worker**	**Onsite Public**	**Offsite Public**	
Distance:	369 m	4,300 m	12,580 m	
X/Q:	3.50E-03	7.55E-05	1.88E-05	s/m3
Breathing Rate:	3.35E-04	3.29E-04	3.29E-04	m3/s
Unit DCF:	1.70E+07	2.66E+07	2.66E+07	rem/ci
Total Dose:	**4.19E+00**	**1.39E-01**	**3.44E-02**	**rem**
Consequence:	Low	na	Low	

User-Defined Source Material

2 nuclides

Note: Full printout is 36 pages. Typical cases only need the first few pages.

	User Input	Default	
MAR unit:	ci		
Enter activities or masses?	1		enter activity per ci

Nuclide	Curies per ci	Specific Activity, Ci/g	Grams per ci	FGR Index	2.310E+00 Fraction
Sr-90	8.57E-01	1.37E+02	6.28E-03	164	2.72E-03
Pu-239	1.43E-01	6.21E-02	2.30E+00	776	9.97E-01

Appendix E
Basis for ARF and RF Values

Appendix E

E.1 Accident Scenarios 3.4.1 and 3.4.5

This section documents the justification for the ARF and RF values used on accidents involving the 291-S sand filter - Section 3.4.1 Seismic Event and Section 3.4.5 Sand Filter Load Drop.

The following calculations show the ARF and RF values taken from PRC-STD-NS-8739, Table D-1 are conservatively bounding using the methodology provided in DOE-HDBK-3010-94, Section 5.3.2.

For scenario 3.4.1, the 291-S Sand Filter roof fails due to the stack dropping on it during a seismic event. As discussed in Section 3.4.1.1.2, the stack is 186.1 ft from the northeast corner of the sand filter. Since the stack is 200 ft tall, this results in the top 13.9 ft of the stack is able to directly strike the 291-S Sand Filter. This value is rounded up to 15 ft for conservatism.

In the calculation, for simplicity, the top of the stack is modeled dropping straight down from its resting height rather than following an arc trajectory.

As discussed in Section 2.3.2.4, the stack is 200 ft high above grade. It is constructed of reinforced concrete, with a free-standing stainless steel liner, which has a 45 in. inside diameter. Specification HW-4317 states the liner is made from Type 347 stainless steel, and is expected to be 12 gage above the first 10 ft. The specification states: "the thickness of the concrete shall be determined by the contractor". No dimensions were found on any engineering drawings that were reviewed, so a thickness for the concrete on the T/U/B stacks was used (90 in. outer diameter, 6 in. thickness, from CP-55076 Section 2.1.1).

Rather than using the height at the center of the 15 ft stack section, the full 200 ft was used to accommodate for the 5.5 ft of space between the roof and the sand filter media. For simplicity and conservatism, no credit was taken for the dissipation of kinetic energy when the stack strikes the roof. The full force of the stack strikes the MAR, in addition to the force of the entire roof collapsing.

The impact of the stack and sand filter roof on the contaminated sand and gravel is treated in a similar way as an explosive stress shock on a non-combustible, contaminated surface. The kinetic energy of the falling roof is converted into a TNT equivalent quantity. Then, following Section 5.3.2.1.2 of the DOE handbook for soil or soil-like powders (aggregated, compacted powder), the ARF and RF for the mass of soil suspended in the crib is calculated as $0.8 \times$ TNT equivalent for the explosion, with an RF 0.25. The amount of the radioactive contaminant made airborne is estimated by multiplying the mass of sand made airborne by the concentration of the contaminant in the sand.

> The kinetic energy imparted on the sand filter is the potential energy of the entire concrete roof, plus the potential energy of the top 15 ft of the 291-S stack. The mass of the concrete roof is found based on the volume of concrete falling into the filter times the density of the concrete. The ceiling area, above the active filter surface, is 85 ft (25.9 m)

by 85 ft (25.9 m) with a thickness of 6 in. (0.15 m) (H-2-8454 Rev. 3). A density of 2,450 kg/m^3 is used for concrete. The mass of the concrete slab, $slab_{mass}$ is therefore:

$$slab_{mass} = (2{,}450\ kg/m^3)\ (25.9\ m)\ (25.9\ m)\ (0.15\ m)$$
$$= 246{,}523\ kg$$

If the stack falls in the worst possible direction (southwest), the top 15 ft of the stack will strike the filter roof. The top 15 ft of the stack is assumed to be 11,808 kg (26,032 lb.), and the drop is calculated from 200 ft (60.96 meters). This mass includes both a 15 ft tall concrete section of the stack, as well as a 15 ft tall section of the liner. The kinetic energy of the falling stack is equivalent to its initial potential energy or

$$E = M \times H \times g_a$$
$$= (11{,}808\ kg) \times (60.96\ m) \times 9.8\ m/s^2)$$
$$= 7.1 \times 10^6\ J$$
$$= 1.7 \times 10^6\ cal$$

Where:

E = the kinetic energy of the falling mass at impact (J or cal)

M = the mass of the falling stack (kg)

H = the height above the roof surface, (m)

g_a = the acceleration of gravity, (9.8 m/s^2).

The surface of the sand filter is about 5.5 ft (1.7 m) beneath the bottom of the concrete slab cover (H-2-8454 Rev. 3). The kinetic energy of the falling material is equivalent to its initial potential energy or

$$E = M \times H \times g_a$$
$$= (246{,}523\ kg) \times (1.7\ m) \times 9.8\ m/s^2)$$
$$= 4.1 \times 10^6\ J$$
$$= 9.7 \times 10^5\ cal$$

Where:

E = the kinetic energy of the falling mass at impact (J or cal)

M = the mass of the falling concrete (kg)

H = the height above the waste surface, (m)

g_a = the acceleration of gravity, (9.8 m/s^2).

At a standard conversion of 1,100 cal/g of TNT (DOE-HDBK-3010-94, pages 7-59), the sum of these energies, 2.65×10^6 cal, corresponds to a TNT equivalent of 2.41 kg. The amount of suspended soil is:

$$Soil_{suspended} = 0.8 \times TNT_{eq}$$
$$= 0.8 \times 2.41 \text{ kg}$$
$$= 1.93 \text{ kg (soil)}$$

The entire inventory of the sand filter is estimated at 0.548 kg of plutonium and 0.058 kg of strontium. For conservatism and simplicity, the MAR is assumed to be homogenously distributed throughout the sand filter material. In reality a higher concentration of MAR is expected to be about 3 ft down (see Section 3.4.1.1.2). Using a homogenous distribution, the average MAR concentration of the soil is

$$MAR_{conc} = \text{Total quantity of MAR/ Volume of filter media}$$
$$= (0.548+0.058 \text{ kg}) / (25.9 \text{ m} \times 25.9 \text{ m} \times 2.0 \text{ m})$$
$$= 4.56\text{E-04 kg/m}^3$$

Therefore, a value of 4.56E-04 kg/m^3 is used as the current concentration of MAR at the sand filter surface to estimate the quantity of material released. With a soil density, $\rho soil$, of 2,300 kg/m^3, (ARH-2207, Table 2), the quantity of MAR suspended is:

$$MAR_{suspended} = Soil_{suspended} / \rho soil) \times MAR_{conc}$$
$$= (1.93 \text{ kg} / 2{,}300 \text{ kg/m}^3) \times 4.56\text{E-04 kg/m}^3 \times 1{,}000 \text{ g/kg}$$
$$= 3.83\text{E-04 g}$$

For use in RADIDOSE calculation, the equivalent ARF is the ratio of estimated suspended plutonium mass divided by the initial MAR, 0.606 kg, or

$$ARF = MAR_{suspended} / MAR_{total}$$
$$= (3.83\text{E-04 g}) \times (10\text{-3 kg/g}) / (0.606 \text{ kg})$$
$$= 6.32\text{E-07}$$

Using methodology provided in DOE-HDBK-3010-94, these calculations show that the ARF and RF values of 1.2E-05 and 0.25 provided in PRC-STD-NS-8739, Table D-1 would conservatively bound this accident. This also bounds the Sand Filter Load Drop, Section 3.4.5, as the calculated ARF value is smaller due to less energy being imparted on the MAR by a fully loaded CONEX box than the top 15 ft of the stack dropping from 200 ft.

E.2 Accident Scenario 3.4.7

This section documents the justification for the ARF×RF values used in Section 3.4.7 Internal Equipment Deflagration. The discussion below was taken from HNF-15500, Plutonium Finishing Plant Deactivation and Decommissioning Documented Safety Analysis, Revision 12, Section 4.2.4.3 Material at Risk Inventory in Building 291-Z. This particular discussion comes from 291-Z which had a large amount of MAR due to a process upset that resulted in Pu nitrate being forced into the line.

HNF-15500, Revision 12:

The holdup material in the abandoned 26 in. vacuum piping in 291-Z piping is determined to be plutonium nitrate from a process upset involving past liquid transfers. This conclusion is based on the following information.

- Shift logs show that overflow of the system traps during vacuum transfers of concentrated plutonium nitrate solutions from the PR cans into the facility process tanks was a known cause of escape of plutonium into the vacuum system headers
- In a letter from D. T. Crawley, Plutonium Process Engineering to W. J. Gartin, Manager, Weapons Manufacturing division, dated Nov. 23, 1964, D. T. Crawley stated that on Friday Nov. 6 and Saturday Nov. 7, 1964, 135 L of solution was removed from the 26-in. vacuum header. The solution was plutonium nitrate and nitric acid. The header was in Building 234-5Z. This is an indication that the solutions could have gone past the intended transfer tank.
- In a letter (65490-87-085) from H. H. Hopkins, Advanced Process Group to The PFP Issues File, dated April 30, 1987, H. Hopkins stated that there was contamination in the 291-Z sump. The source of the contamination was believed to be the 26-in. vacuum system. This is further indication that the solution from liquid transfers was inadvertently transferred all the way down the line to the vacuum pumps due to a process upset.

It is assumed that any plutonium nitrate/nitric acid mixture contained in the vacuum system piping is now dry. The references below show the appearance and form of the solid that likely formed in the vacuum system.

- The Nuclear Weapons Complex: Management for Health, Safety, and the Environment, Appendix D, "Plutonium," states that the heating of plutonium nitrate in air tends to produce gummy residues (National Research Council 1989).
- BNWL-931, Plutonium Release Studies – Part IV: Fractional Release from Heating Plutonium Nitrate Solutions in Flowing Air, provided the results of tests performed on air-dried plutonium nitrate. In the tests, plutonium nitrate was placed in a dish. Room temperature or heated air flowed over the solution until it dried. Typically 2-3 ml of solution was used. The airflow rate was 10 cm/s to 100 cm/s. The air temperature ranged from ambient to 110°C. For the case of air drying at ambient temperature, the solids remaining on the dish were dark brown to dark green in color (depending on airflow rate) with an irregular glazed surface.

- HW-69738, Parameters in the Conversion of Plutonium Nitrate to Plutonium Trichloride by a Direct Calcination-Fluid Bed Chlorination Process, provided the results of a parametric study of conversion of plutonium nitrate. In the conversion process, plutonium nitrate was placed in a calciner having an agitated bed. The solution was heated to drive off the water and free nitric acid. Further heating decomposed the nitrate creating plutonium oxide. In the summary, the authors stated that for plutonium nitrate solutions containing 200-275 g, Pu/L, batch calcination (heating without stirring or agitation) sometimes resulted in a solid mass requiring some sort of breakout and size reduction, while the continuous process (agitation, flow) gave a powdery or granular material.
- BNWL-1941, Results of Research to Evaluate Solid Plutonium Nitrate as a Safe Shipping Form, Section E, "Pilot Plant Work," provided the results of large-scale production of solid plutonium nitrate. In the test, 920 g of plutonium nitrate was added to an evaporation vessel. Evaporation was carried out under 180 torr with final evaporation to 9 torr. The resultant solid was a large dark green mass that was taken as a single piece from the evaporation vessel.

The references show that air-dried plutonium nitrate is found as a large solid mass (i.e., has a small respirable fraction [RF]), that is not easily broken up into respirable sized pieces and from which little is suspended by airflow. This is almost the opposite of the light, fluffy, powder, typically used in tests that provide the airborne release fraction (ARF) and RF in DOE-HDBK-3010-94, Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities. As such, it is concluded that the ARF×RF values for holdup remaining in 291-Z vacuum system equipment should be at least a factor of 10 lower than those used for releases of Pu oxide powder upon which the accident analyses are based. This reduction in ARF×RF will be incorporated into a combined ARF×RF value for accidents involving vacuum system equipment when calculating source term quantities for consequence calculations.

This reduction in ARF×RF by a factor of 10 for fires involving powder or contamination off metal surfaces is supported by the following tests shown in DOE-HDBK-3010-94.

The ARF, taken from Section 4.4.1.1 for the accident in which PuO2 particles are heated under a flowing airstream is 6E-3. The RF is 0.01. The ARF×RF is 6E-5. The bounding ARF for heating air dried Pu nitrate under flowing air is 1.5E-3. The RF is 1E-3. The ARF×RF is 1.5E-6. The ratio of the ARF×RF for oxide powder, the material historically used in the accident analysis for 291-Z accidents to the ARF×RF for air dried Pu nitrate is 40. That is, the ARF×RF for air dried Pu nitrate is a factor of 40 less. Note also that even if the same ARF is used in both cases, Section 4.4.1.2, page 4-59 states that a RF of 1E-3 for air dried Pu nitrate is bounding over the values of 1E-5 to 1E-8 usually seen.

The same arguments are made for a factor of 10 reduction in ARF×RF for explosions. DOE-HDBK-3010-94 does not provide experiments from which one can develop an ARF and RF for a release of Pu that is adhered to the surface and to adjacent particles during explosions or impact. However, in the case of fire, the release mechanism is the ability of flowing air to loft the powder. Since the contamination is dried and adhered to the surface, lofting is more difficult. The ARF and RF for powders in a fire is driven by suspension from the surface by air flow. In explosions air flow suspends the oxide from the surface as well (see DOE-HDBK-3010-94, Section 5.3.2.3, Venting of Pressurized Gases over Solids). That means that the ARF and RF for explosions involving air-dried UNH is at least a factor of 10 less than it is for loose oxide powder.

A similar argument is made for impact. While there is no guidance from DOE-HDBK-3010-94 for the variance of ARF and RF with chemical form, it is clear from arguments above that the ARF is likely less as the material is better adhered than is loose oxide used in the tests and the RF is less due to adherence to adjoining particles creating solid masses. As a result, a reduction of a factor of 10 is reasonable.